1968

Construction time and cost control using the IBM Project Management System/360

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Department:

CONSTRUCTION TIME AND COST CONTROL
USING THE IBM PROJECT MANAGEMENT SYSTEM/360

BY

JAMES DONALD BAILEY, 1944

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THESIS

submitted to the faculty of

THE UNIVERSITY OF MISSOURI - ROLLA

in partial fulfillment of the requirements for the

Degree of

MASTER OF SCIENCE IN CIVIL ENGINEERING

Rolla, Missouri

1968

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ABSTRACT

The object of this investigation was to determine the advantages or disadvantages involved in the use of the IBM Project Management System/360 as a time and cost control tool as compared to the methods presently used by construction contractors in the small to medium size range.

The methods used by three construction contractors were investigated in order to acquire a sample of methods presently used.

It was determined from the investigation that a number of advantages could be obtained which would provide better control of a construction project.

It was also decided that a detailed investigation concerning the cost of installing and using the system must be made in order to determine the feasibility of using the system.

ACKNOWLEDGMENT

The author wishes to express his sincere appreciation to his advisor, Professor James Spooner, and to Dr. Frank A. Gerig, Jr. for their guidance and encouragement during the preparation of this thesis.

The writer is also indebted to each of the three contractors for their cooperation in this investigation.

Appreciation is also extended to the staff and faculty members of the Department of Civil Engineering, University of Missouri at Rolla for their kind assistance.

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I. INTRODUCTION

A. General

The construction industry has for a large number of years made the largest single contribution to the United States economy. In 1965, construction expenditures amounted to approximately 14% of the Gross National Product.(2) Increases in construction contracts of 5% in 1966,(3) 5.5% in 1967 and a predicted increase of 8% in 1968(4) tend to indicate that the construction industry will continue to be a growing part of our economy.

Despite this yearly increase in construction spending a considerable number of business failures plague the construction industry. To cite an example; in 1965, 2,513 construction firms failed, with liabilities totaling $290,980,000. These failures represent 19% of failures in all businesses. The total liabilities of construction contractors who failed in 1965 was 22% of the liabilities of all failing businesses.

The following are problem areas that frequently lead to contractor failure(5):

1. Insufficient profit
2. Incorrect and unrealistic estimating and bidding
3. Inadequate records and cost control
4. Improper buying
5. Overextension
6. Lack of proper management and supervision
7. Weakness in the area of human relations
8. Obtaining business

9. Contracting in foreign markets - too far from their base of operations
10. Failure to consider the long range view

It is easily recognizable that a large part of these areas are concerned with problems in the area of estimating and time and cost control.

B. Purpose of Investigation

In recent years competition among contractors has become keener. The increase in material, labor, and equipment costs have also presented contractors with additional management problems.

These factors tend to indicate that new and more scientific methods of time and cost control need to be adopted by the contractors. One such method is the IBM Project Management System/360, which makes use Program Evaluation and Review Techniques (PERT/Time) for scheduling and time control of the project, and PERT/Cost which is used for cost monitoring of the project.

The purpose of this investigation is to determine the advantages and disadvantages of the use of the IBM Project Management System/360 in time and cost control for construction projects carried out by general construction contractors of a small to medium size.

The methods of three contractors will be investigated in order to determine the time and cost control methods presently used by contractors of this type and size. Although this investigation will not reveal all methods presently in use, it will establish a basis for comparison with the IBM Project Management System/360. This investigation is not intended to show a comparison between the cost of using the IBM system or present contractor methods. However, it has beed estimated from

past use of systems similar to the PMS-360 system after they were installed and personnel trained that the cost of use averages about one-half of one percent of the total project cost.(7) It has also been determined that savings far greater than this amount have been realized. For example, Mr. William Petraglia, who is in charge of a construction control department for the Procter and Gamble Company, stated in a recent presentation that the Construction Division of his company has gained savings of from 5 to 8 times the cost of use for a computerized system which they have developed to aid in controlling construction time and cost.(8)

II. PROJECT MANAGEMENT SYSTEM/360

A. General

The IBM Project Management System for the IBM System/360 is a computerized system for time and cost control using the Program Evaluation and Review Technique (PERT/Time).

The first large project on which PERT/Time was employed was by the U.S. Navy's Special Project Office on the Polaris Program. This extremely large program entailed the co-ordination and execution of some 60,000 time consuming operations, involving some 3800 major contractors. The Polaris Program's goal, of making militarily operational a nuclear powered submarine capable of launching an intercontinental ballistic missle from below the surface of the ocean, was accomplished some 18 months ahead of schedule.(6)

PERT/Time is a management tool which establishes a method of measuring and controlling time expended around a plan of work flow to accomplish the objectives of a project. It is based on a management plan called a network, composed of the work activities, milestone events and the relationships and restraints between these activities and the estimates used to determine the anticipated time occurrence of the activities and events in the network. From this information it is possible to find the critical path of the plan which determines the overall project duration. It is also possible to determine the areas where slack or excess time exists in regard to the completion requirements. With this information known, progress can be reported and measured against the schedule as the work progresses. The IBM Project Management System also makes use of the PERT/Cost system which was developed for use with the basic PERT/Time system in order to provide a good

time and cost control system in one package.

The PMS/360 system is actually nothing more than a method, although it is far superior to most methods to date. It must be recognized that it will not serve as a substitute for good management because it cannot make decisions or insure job control. It simply acts as a very strong tool in the hands of management which when properly utilized can allow management to recognize control problems and aid in making decisions in an attempt to solve these problems.

The system is a versatile one and can be used by almost anyone having a basic knowledge of Critical Path analysis or PERT and having thoroughly studied the users manual for the system. The user need know little about computers and their use.

The information contained in this description of the Project Management System/360 is a summarized presentation of the material contained in the IBM Project Management System/360, Users Manual (H20-0344-0) and is not intended for use in making this system operational.

B. System Description

The PMS-360 system is divided into three distinct parts which are called processors, these being the Network Processor, Cost Processor, and Report Processor. These processors are further subdivided into procedures and subroutines. This subdivision of the system allows the user to determine the processors he needs for his application, and with a knowledge of computer programming he can modify the system to exactly fit his specifications at any level. A discussion of each of the processors and their subdivisions will now be presented beginning with the Network Processor.

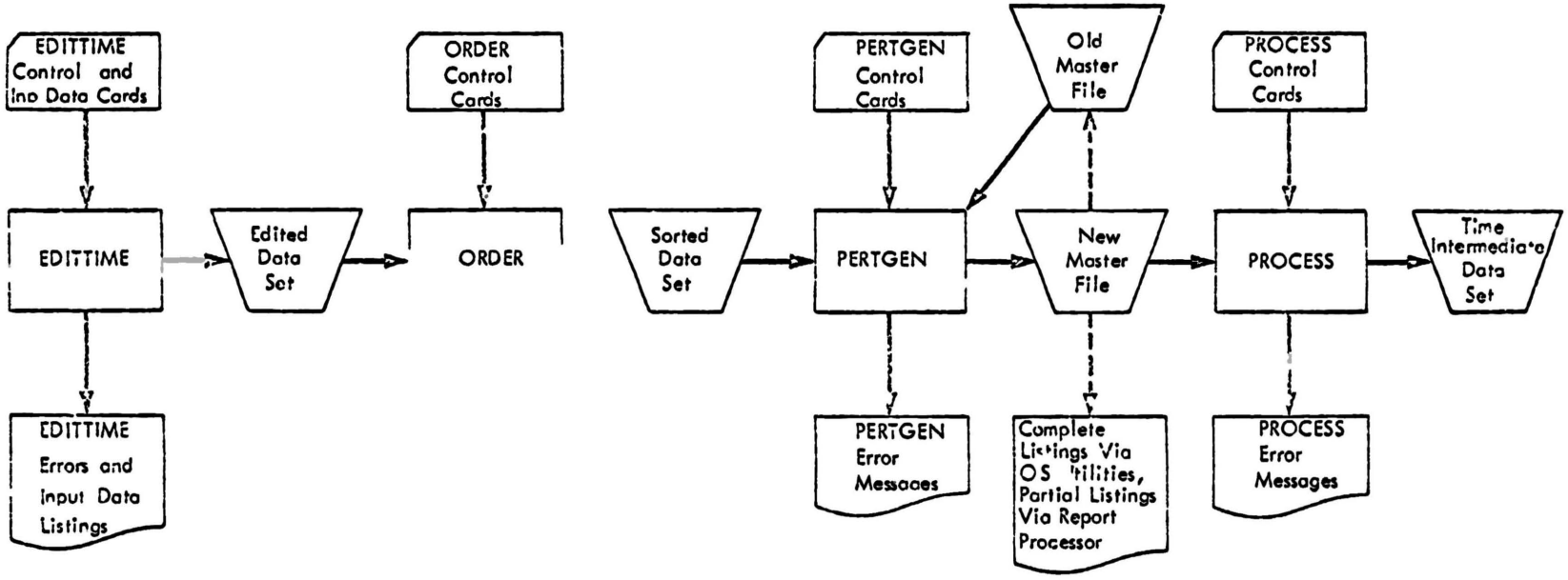
1. Network Processor

The functi n of the Network Processor is to perform PERT or Critical Path analysis on networks. The Network Processor is also used for updating the network.

The Network Processor consists of four procedures, each having a seperate function. These are EDITTIME, ORDER, PERTGEN, and PROCESS. The procedures are independent in that they may be run at different times or even on different computers. Figure 1 shows the flow of information in the Network Processor. The Network Processor does not produce any printed results. The output d-ta must be either sert to the Report Processor for generation of reports or it may go through the Cost Processor for further calculations before being reported upon.

The first procedure of the Network Processor is EDITTIME. It has the function of editing the input data cards. All of the cards are exhaustively checked for errors. Errors are classified as minor or major. A minor error is one which has been edited and the card containing it can still be included in the edited data set. An example of such an error is an incorrect data field on an activity card. A major error causes the rejection of the data card containing it. An example of such an error is an error in an activity attached to an unknown subnet. Examples showing the information shown on each card type are shown in Figures 3-10. These examples are included only for the purpose of showing the input format used.

The first data card of the Network Processor is the execute card. This card contains control information for the Operating System of the 360 computer. It also contains options which the



EDITTIME

Input	Data cards
Action:	Error checking
Output:	Edited data set, listings.

ORDER

Input:	Edited data set
Action:	Sorting
Output:	Sorted data set

PERTGEN

Input:	Sorted data set, old masterf file.
Action:	Updating, skeleton analysis.
Output:	New master file, listings.

PROCESS

Input:	New master file, process request cards.
Action:	PERT analysis.
Output:	Listings, time intermediate data set.

FIGURE 1. INFORMATION FLOW IN THE NETWORK PROCESSOR

user may decide upon himself. These options include such things as whether minor errors will be edited and listed, whether all input data cards will be listed or only those with errors. It also sets the upper and lower year limits of the calendar.

The other card types in the EDITTIME procedure are designated by two digit numbers. These numbers will now be given with a card description following.

Type 00, The descriptor card (Figure 3): This card has control of the length of descriptions, departments, event-names, etc., and where they appear on the cards. It applies to all networks and subnets on the master file and once it has been used in the original file creation, it must not be changed. It controls the format of information on all of the card types to be described hereafter.

Type 01, Dictionary card (Figure 3): These cards provide EDITTIME with information on the logical relationship of the networks and subnets which contain the following input data. All networks and subnets mentioned on following cards must be defined by a type 01 card, otherwise the cards will not be put in the edited data set. These cards also enable the user to delete complete networks or subnets from the old master file. These cards are always required unless only the calendar is being updated.

The execute card, descriptor card, and dictionary cards must be placed in proper order when input to the computer but the rest of the cards to be listed can be input in random order.

Type 05, Calendar cards (Figure 4): These cards control the Network Processor calendar which is produced by PERTGEN and which is used to calculate results. They may also be used to modify the calendar. An example of the type of calendar produced is shown in Figure 2.

Type 10, Network cards (Figure 5): With these optional cards, the user can add or modify descriptions and data dates of any network.

Type 15, Subnet cards (Figure 5): These optional cards allow the user to add or modify descriptions and data dates of any subnet.

Type 20, Cycle cards (Figure 6): These optional cards contain descriptions of all the cycles used in any one subnet. Cycles are defined as groupings of activities, similar to a department.

Type 30, Activity and special event cards (Figure 7 : These cards contain information on the activities, starts, ends and interfaces. There is one card for each activity and also one card for each start event, end event, and the events which form part of an interface.

Type 31, Activity/event continuation cards (Figure 8): If the user has activity and special event descriptions which are too long for the type 30 cards, they are extended on these opt'onal cards.

Type 40, Milestone event cards (Figure 9): These optional cards identify milestone events, which are events of special importance. This card is also used to flag these milestone

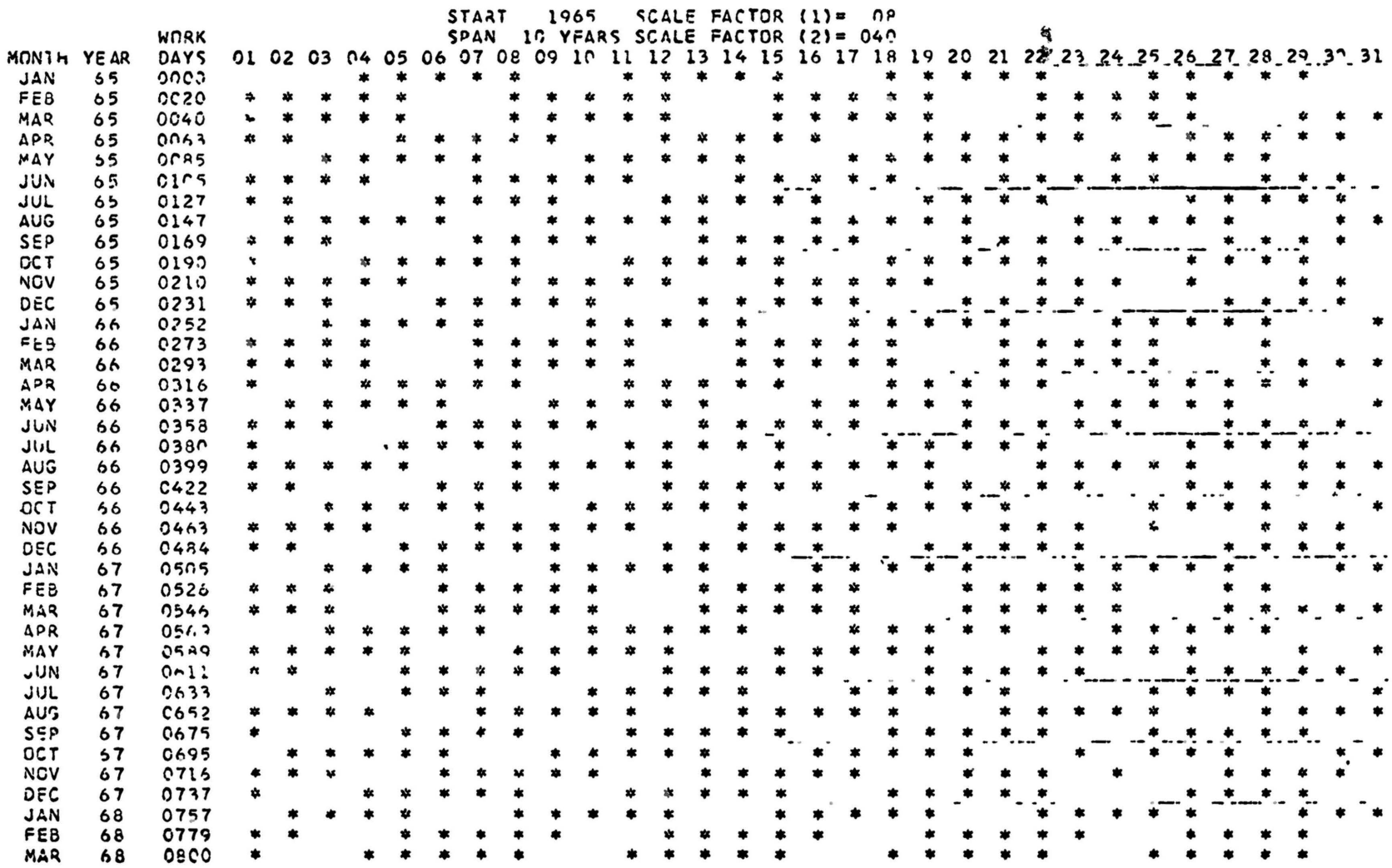


FIGURE 2. WORK CALENDAR

events as being one of nine different levels depending upon importance.

Type 41, Milestone continuation cards (Figure 9): If the user has milestone event descriptions which are too long for the type 40 cards, they can extend onto these optional cards.

Type 42, Hammock cards (Figure 10): These optional cards contain information on any hammock the user is defining. A hammock is one of three available ways of summarizing or condensing a network or subnet.

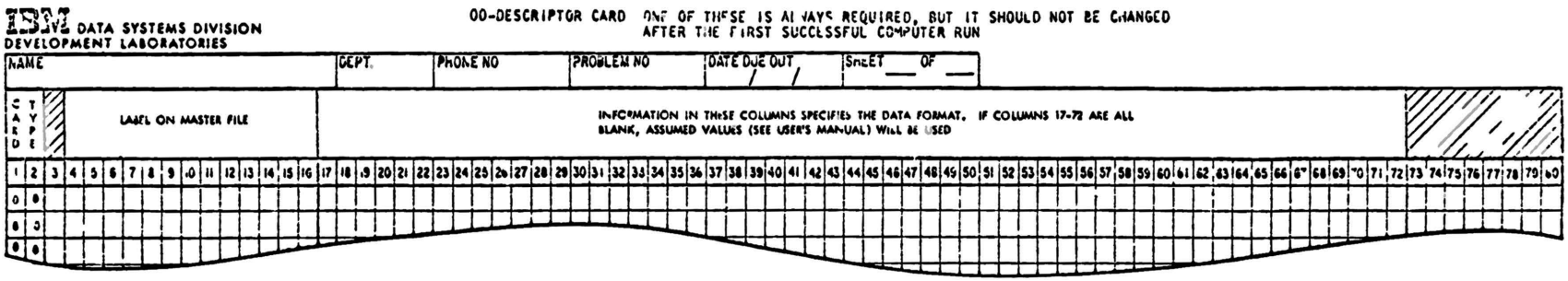
Type 43, Hammock continuation cards (Figure 10): If the user has hammock descriptions which are too long for the type 42 cards, they can extend onto these optional cards.

EOD, End-of-deck card: This obligatory card always comes last and marks the end of the data cards. It contains no user supplied information.

The EDITTIME procedure finishes with a listing of errors and an edited data set.

The second procedure is called ORDER. It has the function of sorting the edited data set produced by EDITTIME into card type numbers within subnets within networks. ORDER contains only one input card which is a control card. It contains options which the user may wish to vary from one run to the next. These options decide whether the procedure is to continue or stop if errors have occurred in EDITTIME. ORDER produces a sorted data set.

The third procedure is called PERTGEN, and has the function



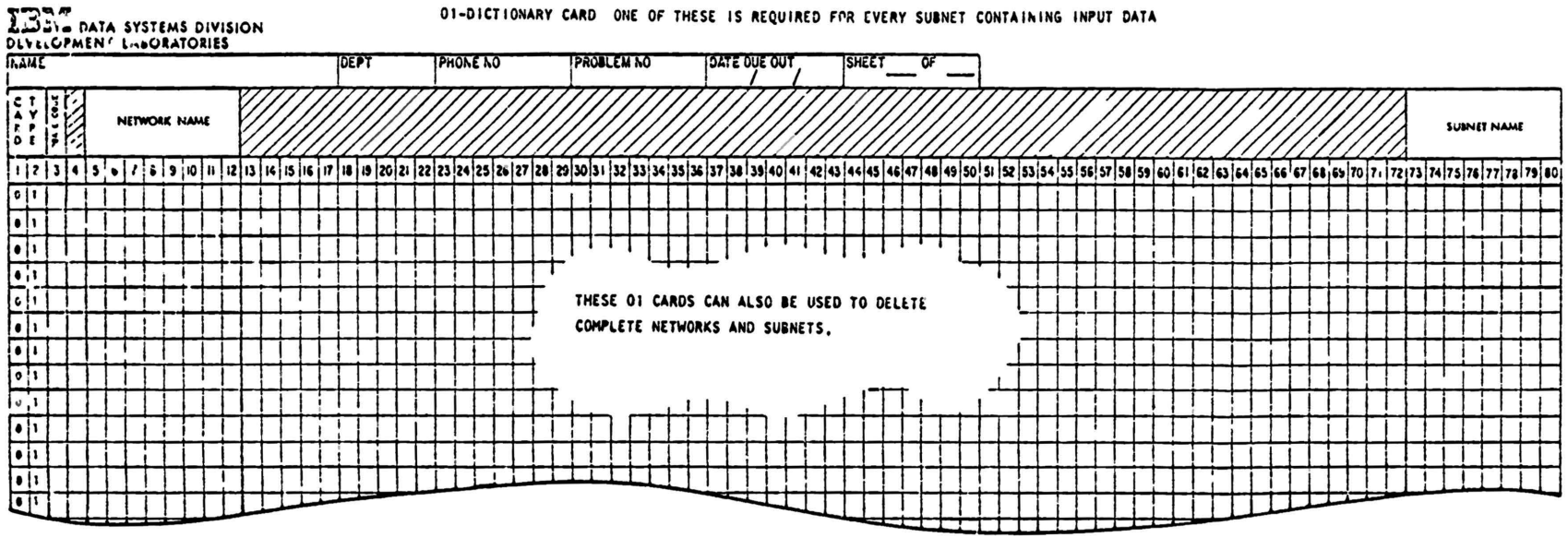
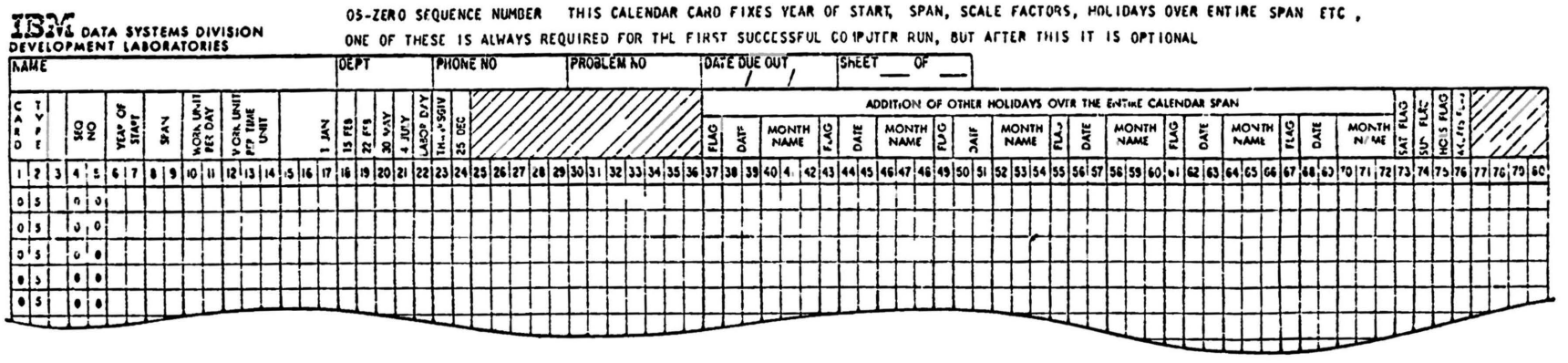


FIGURE 3. NETWORK DESCRIPTOR & DICTIONARY CARDS



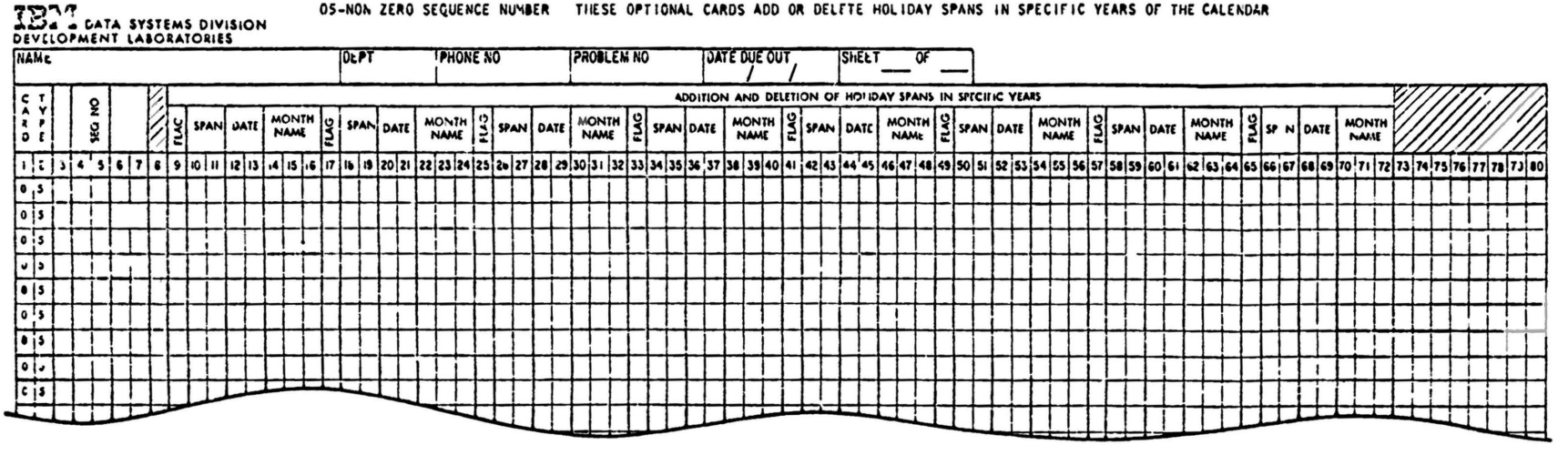
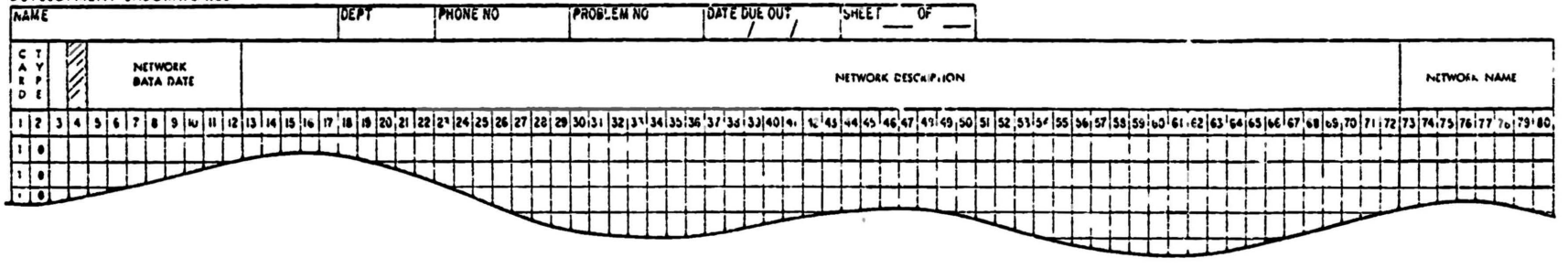


FIGURE 4. PMS/360 NETWORK PROCESSOR CALENDAR CARDS

IBM DATA SYSTEMS DIVISION
DEVELOPMENT LABORATORIES

10-NETWORK CARD THESE OPTIONAL CARDS CONTAIN A DESCRIPTIVE DATA DATE AND A DESCRIPTION FOR A NETWORK



IBM DATA SYSTEMS DIVISION
DEVELOPMENT LABORATORIES

15-SUBNET CARD THESE OPTIONAL CARDS CONTAIN A DESCRIPTIVE DATA DATE AND A DESCRIPTION FOR A SUBNET

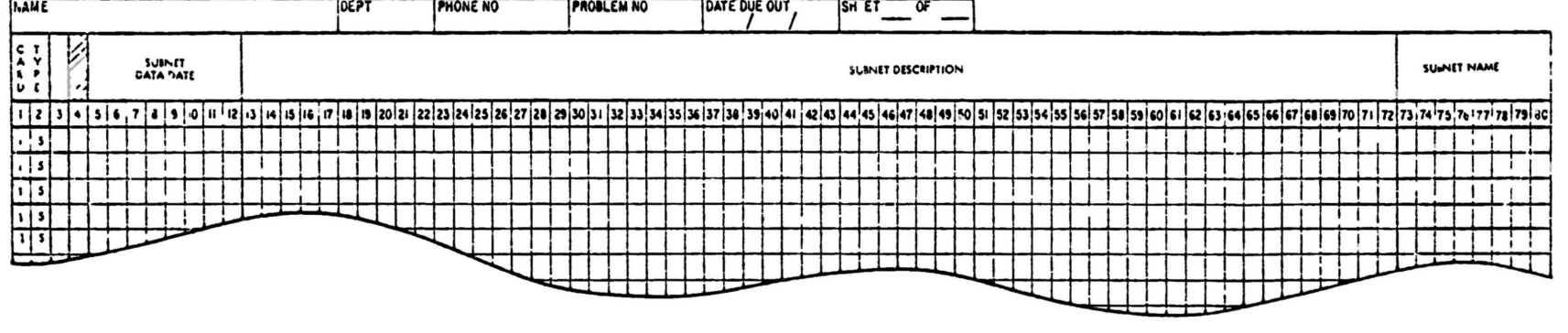


FIGURE 5. NETWORK PROCESSOR AND SUBNET CARDS

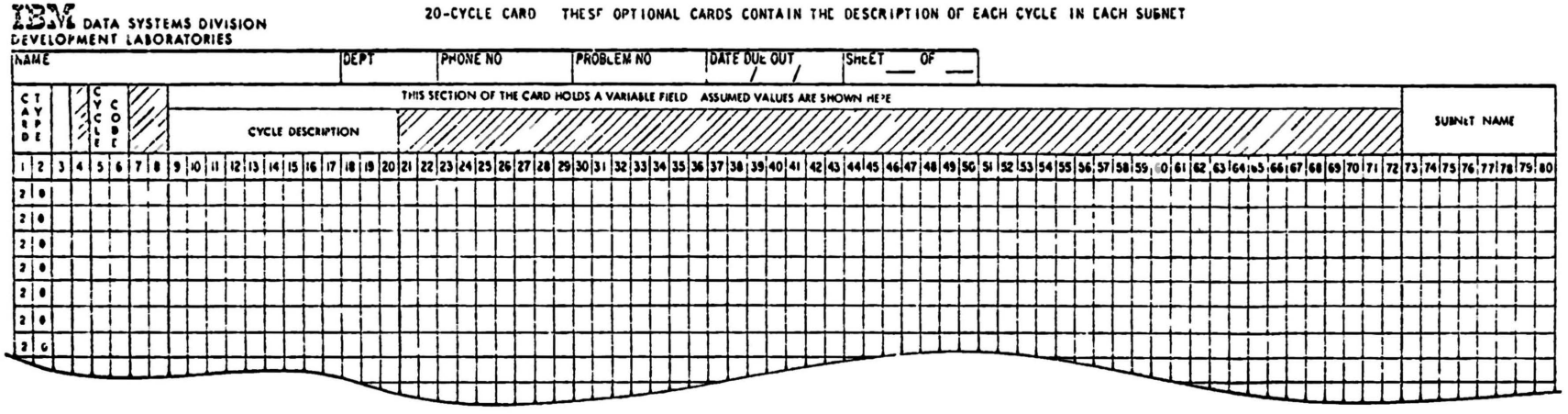


FIGURE 6. PMS/360 NETWORK PROCESSOR CYCLE CARDS

IBM DATA SYSTEMS DIVISION
DEVELOPMENT LABORATORIES

30-ACTIVITY CARD ONE OF THESE CARDS IS REQUIRED FOR EACH ACTIVITY IN EACH SUBNET

NAME | DEPT | PHONE NO | PROBLEM NO | DATE DUE OUT / / | SHEET ___ OF ___

CARD TYPE	UPDATE CODE		CYCLE CODE	SS FLAG	PREDECESSOR EVENT NAME	SUCCESSOR EVENT NAME	TIME ESTIMATES: OPTIMISTIC OR SINGLE	TIME ESTIMATES: LIKELY OR SINGLE	TIME ESTIMATES: PESSIMISTIC	SCHEDULE COMPLETION DATE	ACTUAL COMPLETION DATE	DEPARTMENT NAME	ACTIVITY DESCRIPTION	SUBNET NAME
1 2	3	4	5 6	7	8 9 10 11 12 13	14 15 16 17 18	19 20 21 22	23 24 25 26	27 28 29 30	31 32 33 34 35 36 37	38 39 40 41 42 43 44	45 46 47 48	49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	73 74 75 76 77 78 79 80
3 0														
3 0														
3 0														
3 0														
3 0														
3 0														
3 0														

IBM DATA SYSTEMS DIVISION
DEVELOPMENT LABORATORIES

30-SPECIAL EVENT CARD ONE OF THESE CARDS IS REQUIRED FOR EACH START, END AND INTERFACE EVENT IN EACH SUBNET

NAME | DEPT | PHONE NO | PROBLEM NO | DATE DUE OUT / / | SHEET ___ OF ___

CARD TYPE				SS FLAG	END, END AND INTERMEDIATE INTERFACE EVENT NAMES	START AND START INTERFACE EVENT NAMES	SCHEDULE DATE OF EVENT	ACTUAL DATE OF EVENT (START AND START INTERFACES ONLY)	DEPARTMENT NAME	EVENT DESCRIPTION	SUBNET NAME
1 2	3	4	5 6	7	8 9 10 11 12 13	14 15 16 17 18	19 20 21 22 23 24 25 26 27 28 29 30	31 32 33 34 35 36 37	38 39 40 41 42 43 44	45 46 47 48	49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	73 74 75 76 77 78 79 80
3 0												
3 0												
3 0												
3 0												
3 0												
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3 0												

FIGURE 7. PMS/360 NETWORK PROCESSOR SPECIAL EVENT CARDS

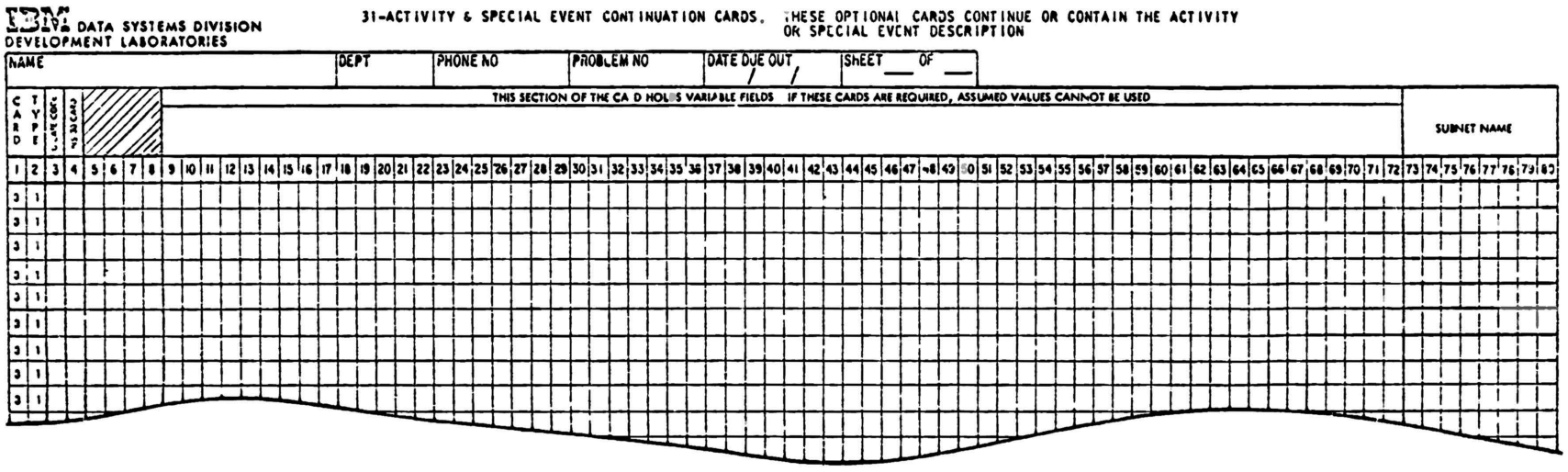
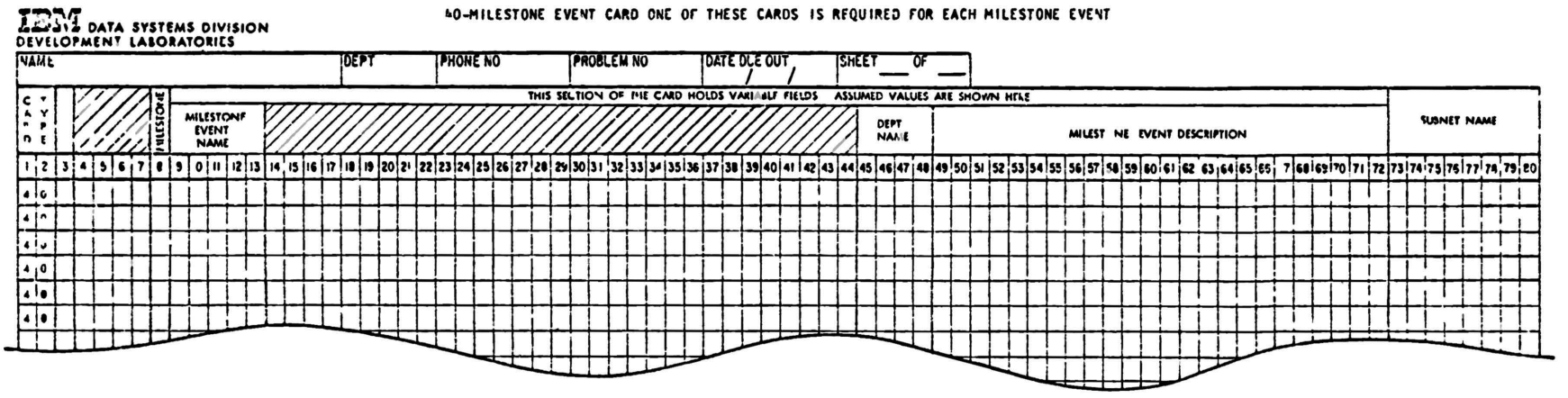


FIGURE 8. PMS/360 NETWORK PROCESSOR ACTIVITY/EVENT CONTINUATION CARD



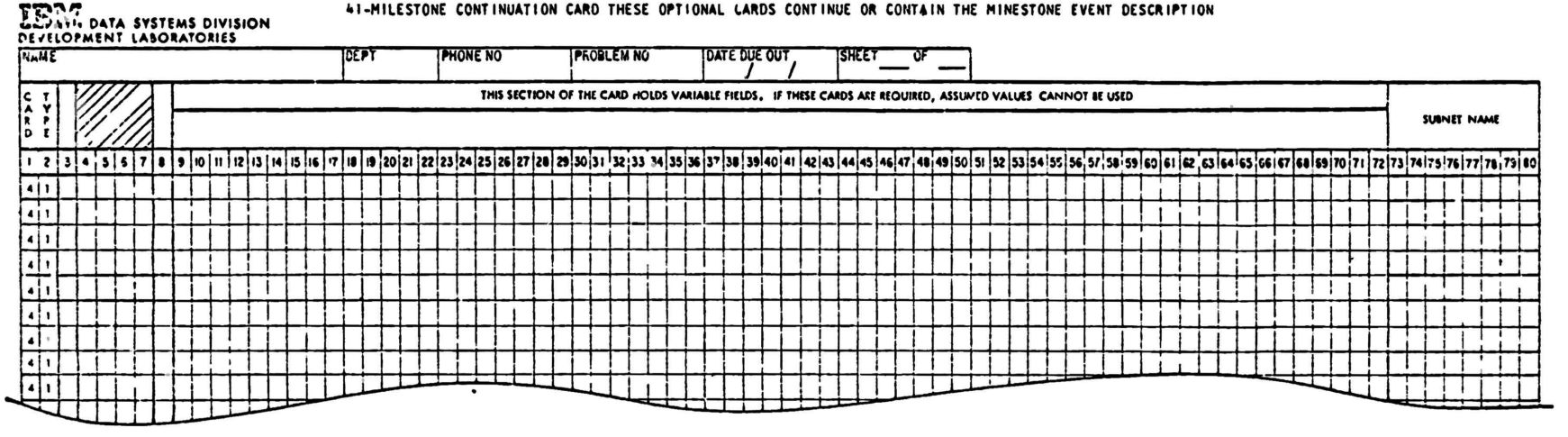


FIGURE 9. PMS/360 NET VORK PROCESSOR MILESTONE EVENT CARDS AND MILESTONE CONTINUATION CARDS

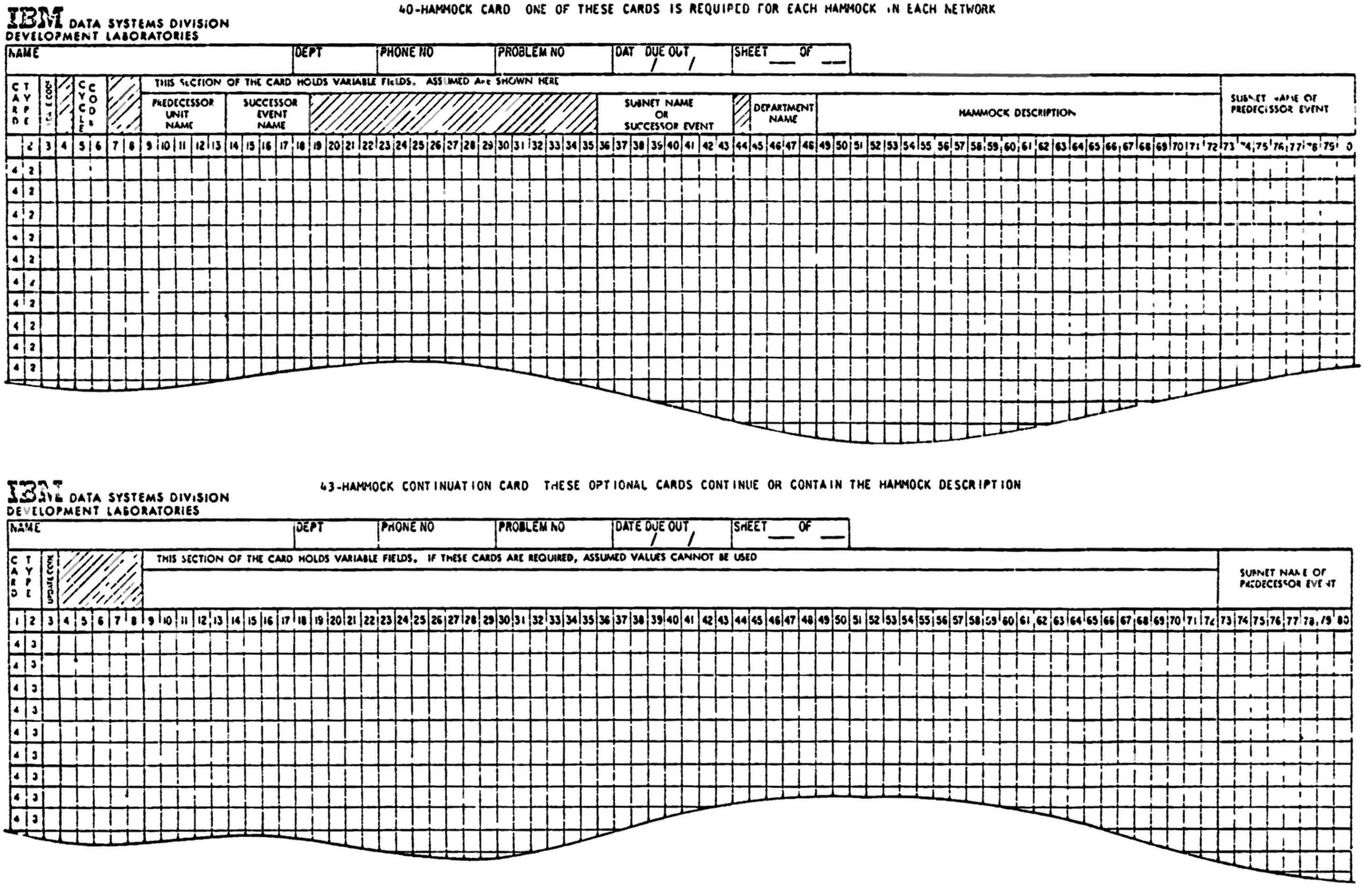


FIGURE 10. PMS/360 NETWORK PROCESSOR HAMMOCK CARDS AND HAMMOCK CONTINUATION CARDS

of generating a master file from the sorted data set produced by ORDER. It is also used to update an old master file. PERTGEN also has only one input card which is a control card. It has the same options as the order control card. PERTGEN produces a new or updated master file to be used in the calculations of the following procedure.

The fourth and final procedure is called PROCESS. Using the information contained in the master file, the PROCESS procedure performs the necessary PERT/Time calculations on the networks and subnets according to the instructions of the PROCESS request card. The PROCESS request card is shown in Figure 11. PROCESS has three types of input cards which are described as follows:

1. The execute card: This obligatory PROCESS control card contains parameters and options which the user may wish to change from one run to another. The parameters enable PROCESS to run efficiently; the options decide whether the procedure is to continue or not if errors haveoccurred in EDITTIME or PERTGEN.
2. PROCESS request cards (Figure 11): If the user requires reports on the networks and subnets in the new master file, the networks and subnets must be processed in one or more of four basically different ways. PROCESS request cards are used to specify the type of proceedings to be done. The four different types of processing are listed and described below.
    a. Detailed activity processing: All activities in a subnet or network are to be analyzed with dates and

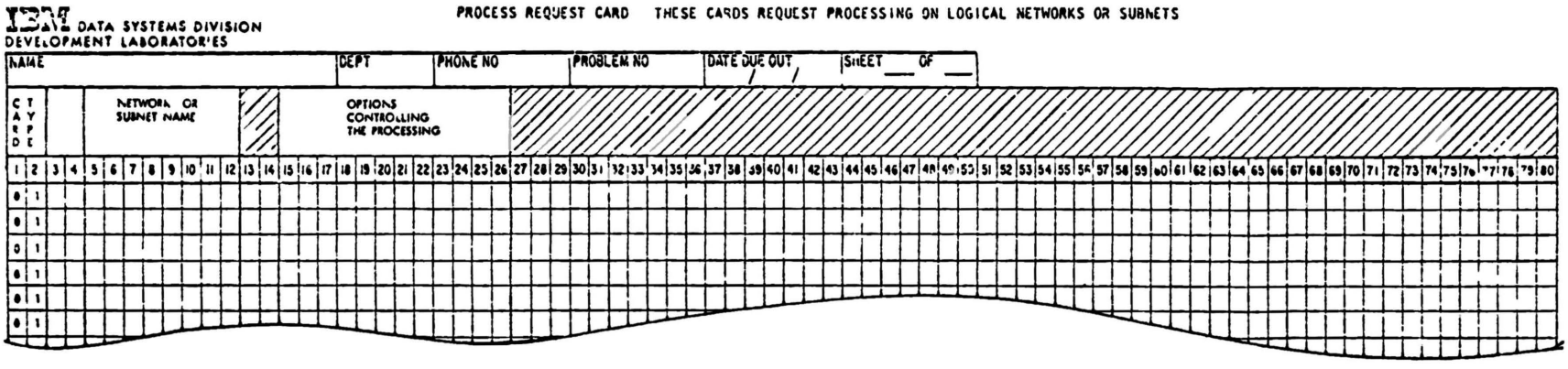


FIGURE 11. PMS/360 NETWORK PROCESSOR PROCESS REQUEST CARDS

slack being produced for them.

b. Summary type-1 processing: The durations of a summary activity is the sum of the durations of the activities along the longest path between the predecessor milestone, or special event, of the summary activity. "Longest" here refers to that path where the sum of the activity durations along it is largest.

c. Summary type-2 processing: The duration of a summary activity is the elapsed time along the longest path between the predecessor milestone or special event and the successor milestone or special event. This allows for delays at intermediate events on the path. "Longest" here refers to that path which has the largest elapsed time.

d. Hammock processing: These reports contain the expected and latest dates of the predecessor and successor events of the hammock and its slack which is defined as the slack of the successor event. The existence or absence of a connected path between the predecessor and successor eventsof a hammock have no effect on its existence, and the work duration has no meaning when applied to a hammock.

3. EOD, End-of-deck card: This obligatory card follows the last process request card.

The calculations which are computed by the PROCESS procedure include expected start, expected finish, latest start, latest finish, primary slack and secondary slack. It can also make what

is called continuous activity calculations of two types. Continuous type-1 activities must start on a workday; but, once they have started they will continue on all calendar days including holidays. If the expected completion date is a holiday this date is printed. When making backward calculations the late finish is required to be a workday but the activity can progress on all calendar days. The slack of the activity will be printed in calendar days, not working days. This type of calculation should be used only in independent subnets, otherwise errors may result.

Continuous type-2 activities must start on a workday and continue only on workdays without delay. The calendar is required to contain a consecutive number of workdays as long as the duration of the activity. The activity cannot be delayed over such things as a weekend or holiday.

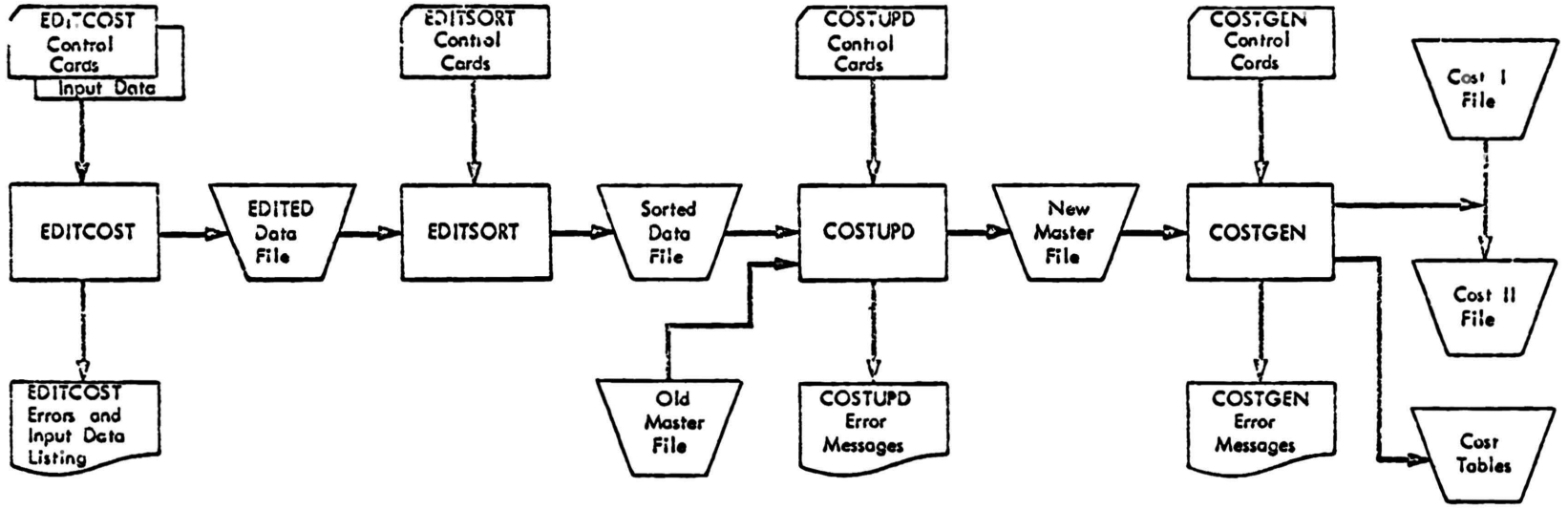
This procedure finishes with listings and a time intermediate data set. To obtain reports of the time analysis, the time intermediate data set is processed by the Report Processor.

2. Cost Processor

The PMS Cost Processor serves as a very valuable tool for cost control at all levels of management. It provides a common basis for comparing cost incurred versus planned cost for work performed built up from the lowest cost level up to the highest or the complete project or organization. It provides information on the impact of change in any part of the project or the organization as a whole. The cost processor is organized in a manner such that a person knowing the basic theory of PERT, and having a knowledge of the theory of cost analysis can use this processor with little difficulty. The system is also organized in such a way that it can be used as an independent cost system. With some knowledge of computers and computer programming the user can modify the system to attain a personalized cost system to fit all of his needs. Figure 12 illustrates the flow of information in the cost processor.

The Cost Processor, like the Network Processor, performs its work in four procedures. These four procedures are EDITCOST, EDITSORT, COSTUPD, and COSTGEN. As in the Network Processor, these procedures can be run independently or even on different computers.

The first procedure used is EDITCOST. The function of this procedure is to edit all of the cost input data cards which will be defined later. The first input card of this procedure is the EDITCOST Control Card. This card is required by the S/360 Operating System. It allows the user to specify such information as The first and last calendar year allowed, whether to accept or reject data cards with errors, and which data cards will be considered in setting the condition code for the following procedures.



EDITCOST

Input: Input data Cards
Action: Error Checking
Output: Edited data set
Data Listing

EDITSORT

Input: Edited data set
Action: Sorting
Output: Sorted data set

COSTUPD

Input: Sorted data set Old Master File
ction: Updating
Output: New Master File

COSTGEN

Input: New aster File
Action: Cost analysis
Output: Cost I File, Cost II File
Cost Tables

FIGURE 12. INFORMATION FLOW IN THE COST PROCESSOR

The procedure then accepts the first data card which is to be the descriptior card shown in Figure 15. This card fixes the format and field length of all the cost data cards. This card is extensively checked for errors and if acceptable, the procedure continues on to the Name/Type Update card which is shown in Figure 15. This card serves as a dictionary of group/subnet names for the edit phase and provides the user with a method of deleting or removing blocks of cards in the update phase. If, after extensive checking for errors in the modification code, the group/subnet names and card types, the card is accepted the procedure continues on to check all of the other cost input cards. The output from EDITCOST is a list of all errors, and an edited cost data file.

The second procedure is called EDITSORT. Its function is to sort the file of edited cost input that is generated by the EDITCOST procedure and reformat the cards in this file to their original input format. The EDITSORT controll card is a standard card required by the S/360 Operating System. It has a standard format and the user does not supply any information. The output from EDITSORT is a sorted data file.

The third procedure is called COSTUPD. Its function is to process and update the data on the old master file or create a new master file if it is the initial run of the system. It uses the sorted data file which was produced by EDITSORT. The control card required by the S/360 Operating System is standard and the only information supplied by the user is whether and old master file exists. The output from COSTUPD is an error list and a new master file.

The foruth procedure is called COSTGEN. Its function can be divided into two parts. First, it transforms such tables as the Work Breakdown Structure, Organization Analysis, Cost Category, and Rate into machine usable language. Second, it removes the desired cost data from the master file and processes it according to the user's needs. The input cards for COSTGEN include the control cards and the cost data input cards.

The control card for COSTGEN is required by the S/360 Operating System. It includes parameter codes for such things as whether files will be generated for the tables mentioned above, whether PERT/Cost or only cost cards will be processed and whether a standard calendar will be printed. The difference between the PERT/Cost cards and the Cost cards is that with the PERT/Cost cards, cost data is accumulated according to the network activities and with Cost cards the data is accumulated according to accounting periods. There are also three parameter cards required for COSTGEN. The first is the "As of" Date card. This mandatory card is used to determine the cutoff or effective date of the cost data. The second is the name card. It tells COSTGEN which subnet/group names are to be processed. If no name cards are submitted, COSTGEN will process both PERT/Cost cards and Cost cards. The third is the Mask card. This card is used to sort and accumulate specific data for reporting. There are the CHGMASK (Charge number mask), RIDMASK (Rate ID combination mask), CCMASK (Cost category mask), RCMASK (Rainbow category mask), and CONMASK (Contract number mask).

The following are the descriptions of the cost data input cards. Examples of these cards are shown in Figures 15-30.

As before, these cards are included only to show the input format. The Cost Descriptor Card and the Name/Type Update cards have been described and are shown in Figure 15.

Type 55, Standard Calendar Cards (Figure 16): This card is used to build a calendar with a maximum span of fifteen years. These cards are optional after a master file has been created. They are then used to modify the Calendar Cards. The first is the 00 sequence number card. This card is used to describe the entire calendar that the Cost Processor will use in its calculations. The second type is the non-zero sequence number card. This card is optional at all times and is used to add or delete holidays as the user wishes. It can also be used to make a certain span of time either all workdays or nonworkdays.

Type 60, Accounting Calendar Card (Figure 17): This card is used with processing of the cost system to produce an accounting calendar with specified accounting periods. These periods may begin or end on any day as desired by the user. The span of the Accounting Calendar Card must be the same as that of the Standard Calendar Card. If an Accounting Calendar Card is not input to the system, it will use the Standard Calendar Card.

Type 61, Work Breakdown Structure Card (Figure 18): The Work Breakdown Structure is the backbone of the cost system. It defines in pyramid or Christmas tree form the work to be done and gives a relationship between the overall project and

each work package. It provides a breakdown of the project into as many as nine levels of detail and allows the user to summarize cost and schedule data of the project for all levels of management. Costs are normally entered at the most detailed level and can then be summarized at any higher level. Charge numbers are assigned to each item at each level and these numbers are used for summarizing. An example of a Work Breakdown Structure is shown in Figure 13.

Type 62, Organization Analysis Table Card (Figure 19): The Organization Analysis Table (OAT) is the basic structure for summarizing cost information according to performing department or up to successively higher levels of management. The OAT provides up to nine levels of organization. Cost data is normally entered at the lowest level and summarized to the desired level. This organization provides the system with the capability of multiproject control on the same system. An example of an Organization Analysis Table is shown in Figure 14.

Type 63, Cost Category Cards (Figure 19): These cards supply a description of as many cost categories as the user may want to define and group together within the limits of the rate ID's. The rate ID consists of three variables which are the costing code, performing department, and resource code or category. Examples of cost categories that might be defined are management, engineering, labor, etc.

Type 64, Rainbow Category Cards (Figure 20): The purpose of

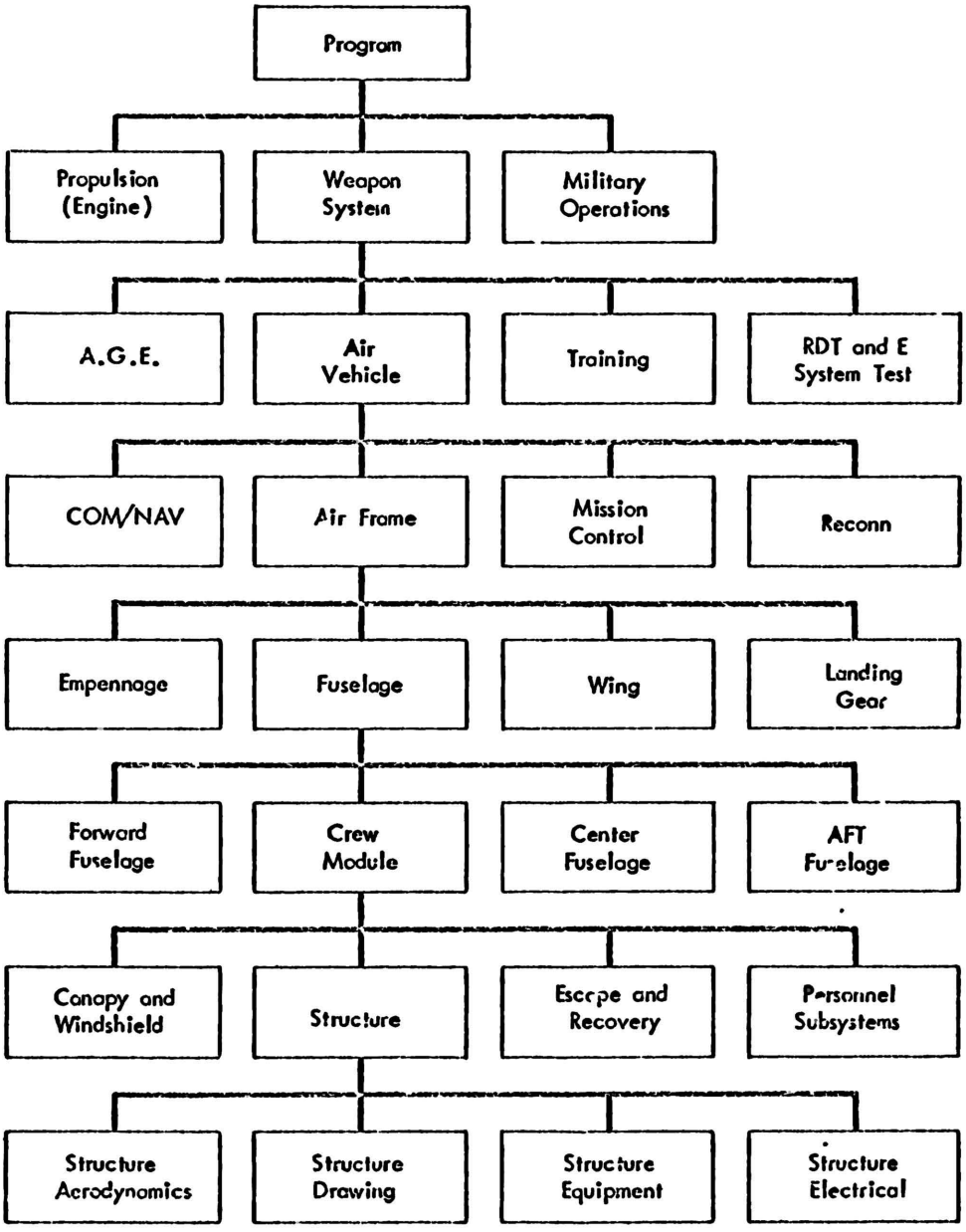


FIGURE 13. SAMPLE WORK BREAKDOWN STRUCTURE

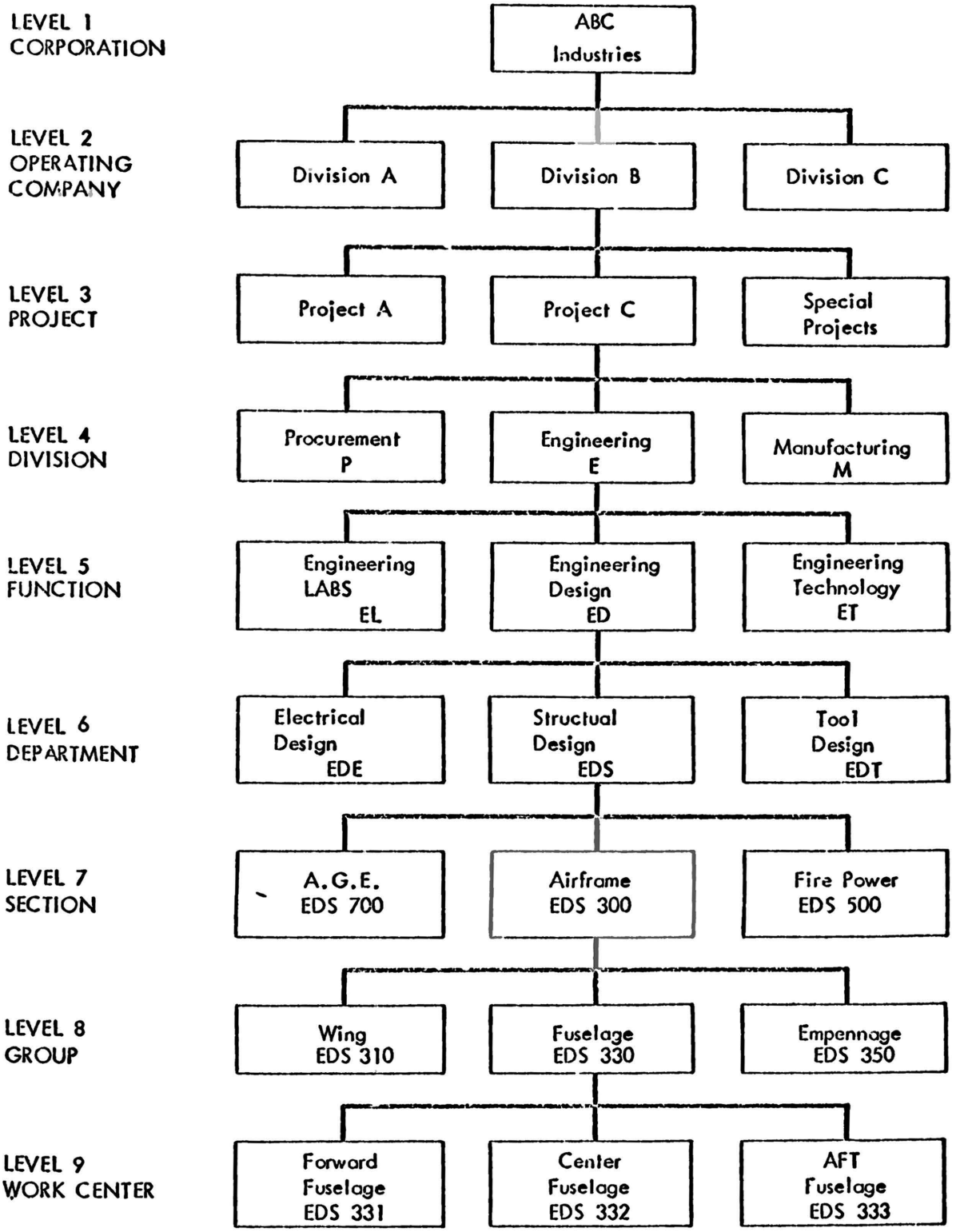


FIGURE 14. SAMPLE ORGANIZATION ANALYSIS TABLE

this input is similar to that of the Cost Category input. It is intended to provide selected summaries of resource codes to fit user's requirements. It provides for combining groups of manpower and/or resources to report seperate summaries on their combined manhour performance.

Type 65, Charge Number Rate Card (Figure 20): This card is used to introduce indirect rates to the Cost Processor where they can be tied to the Work Breakdown Structure. It provides for entering rates as a percent of cost for a charge number and at different cost levels. These rates are entered by accounting period. They can be applied to either direct dollars or total dollars and summed upward through the Work Breakdown Structure.

Type 66, Rate Table Cards (Figure 21): The Rate Tables contain the unit or direct rates, overhead or burden rates, and the unit adjustment factors for a project. The information is used to specify either manpower or material classifications and the appropriate rates that will be used to arrive at total dollars. The Rate Table is master file based and is therefore multiproject oriented.

Type 67, Contract Description Card (Figure 21): This card is used to provide an alphameric description of the contract number or project name.

Type 68, Charge Number Description Card (Figure 22): This card is used to provide an alphameric description for each

charge number and/or summary number. It also provides the time span for the charge number.

Type 70, PERT/Cost.I Cards (Figure 22): This card is used to tie all costs to an event within a subnet of the network. This is done by identifying an activity between two events in the same subnet. The event occurring before the event in question is called the "predecessor event" and the one after, the "successor event". Between these two events, cost may be summarized over the total span or only a part of it. Each cost that is entered must be identified by the type of information such as budget, actual, or estimate.

Type 71, PERT/Cost II Cards (Figure 23): This card also ties the costs to an event in a subnet or network. These costs can then be projected forward using a linear projection. They can be projected for a specified period of time according to the users desire. The cost will be allocated to each accounting period on the basis of the number of workdays in each accounting period.

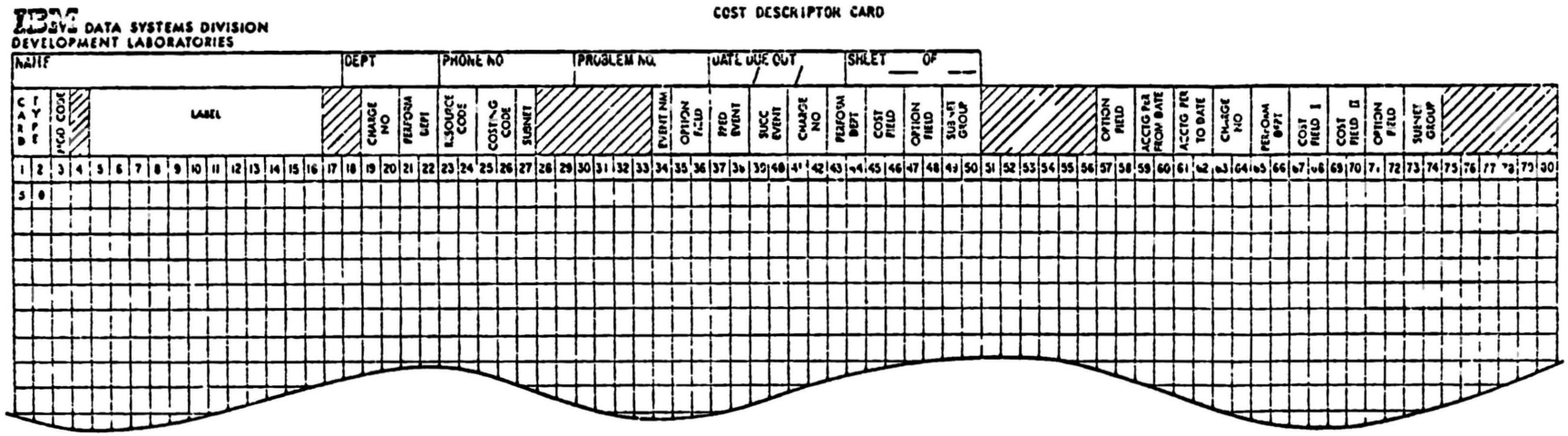
Type 72, Cost Milestone Cards (Figure 23): These cards are used to specify events in the PERT/Time network that will be cost milestones. The network can then be summarized by levels. These milestones or summarized events can correspond to the charge number cost levels.

Type 81, Cost I Cards (Figure 24): This card is used to introduce cost by either of two ways. First, cost can be

introduced by individual or single accounting periods. Second, they can be introduced from one accounting period to another. These costs are not associated with PERT/Time events. Each value of input must be identified as to the type of information to be processed such as budget, estimate or actual.

Type 82, Cost II Cards (Figure 24): This card introduces cost using the accounting period FROM date to an accounting period TO date. The accounting periods are broken into days so the user can specify the exact day that costs are to begin or stop. The costs are not associated with the PERT/Time events. Each cost value must be identified as to the type of information that will be processed such as budget, actual, or estimate.

The output from COSTGEN is a listing of errors and the Cost I and Cost II Intermediate Files which are passed on to the Report Processor for report generation.



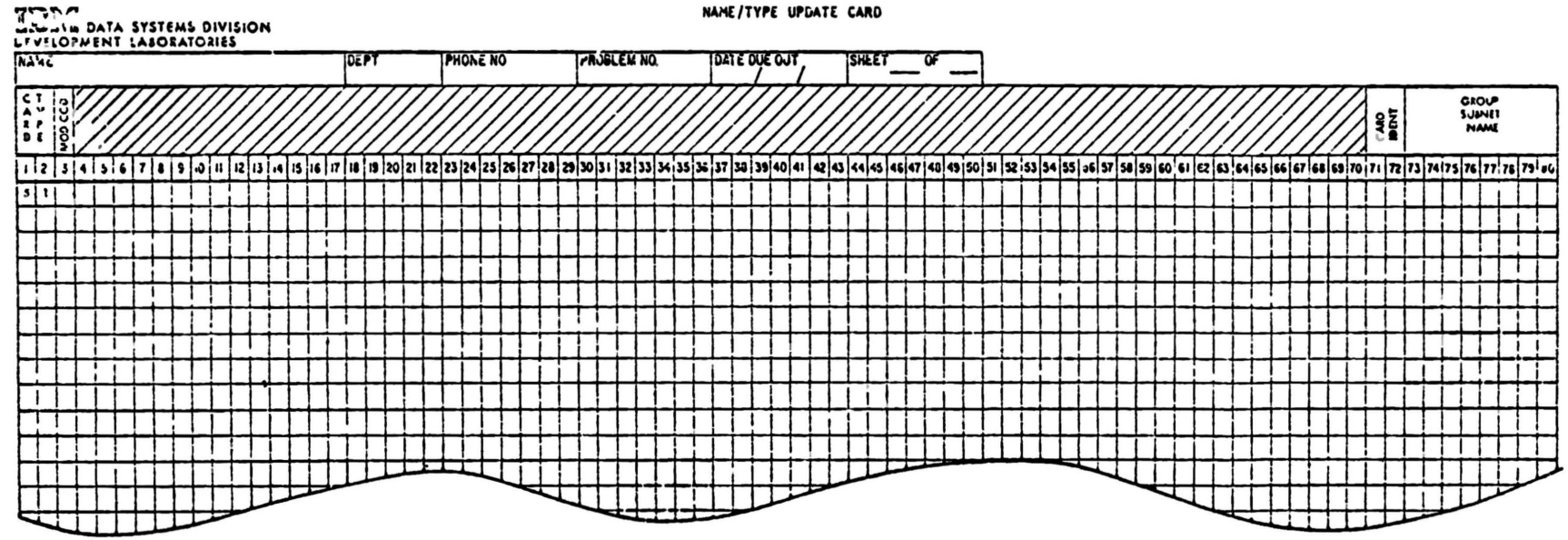
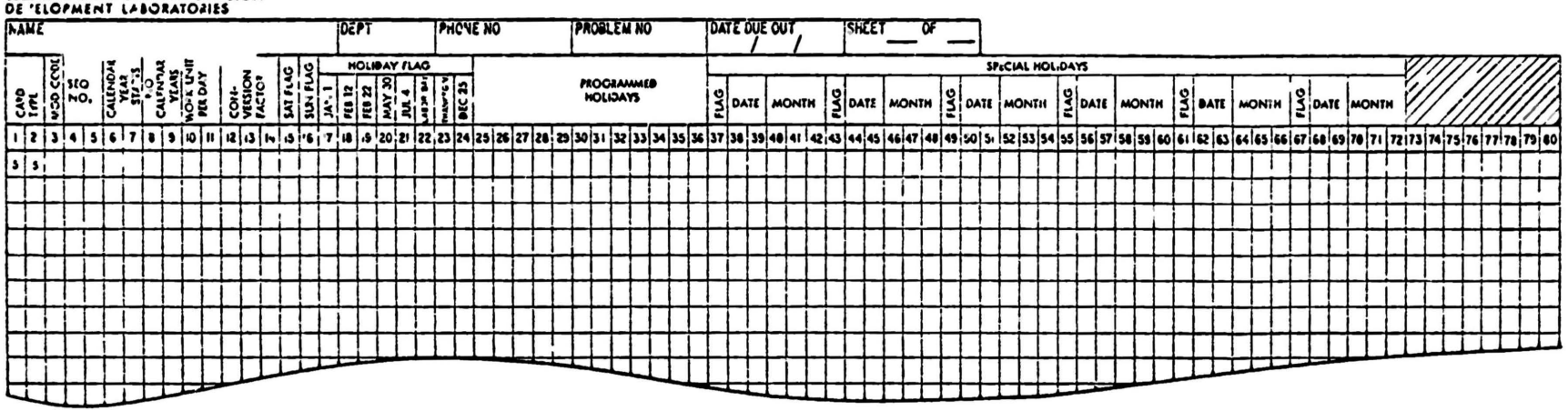


FIGURE 15. PMS/360 COST PROCESSOR, COST DESCRIPTOR AND NAME/TYPE UPDATE CARDS

IBM DATA SYSTEMS DIVISION
DEVELOPMENT LABORATORIES

STANDARD CALENDAR CARD I (SEQUENCE NUMBER 00)



IBM DATA SYSTEMS DIVISION
DEVELOPMENT LABORATORIES

STANDARD CALENDAR CARD II (NON-ZERO SEQUENCE NUMBERS)

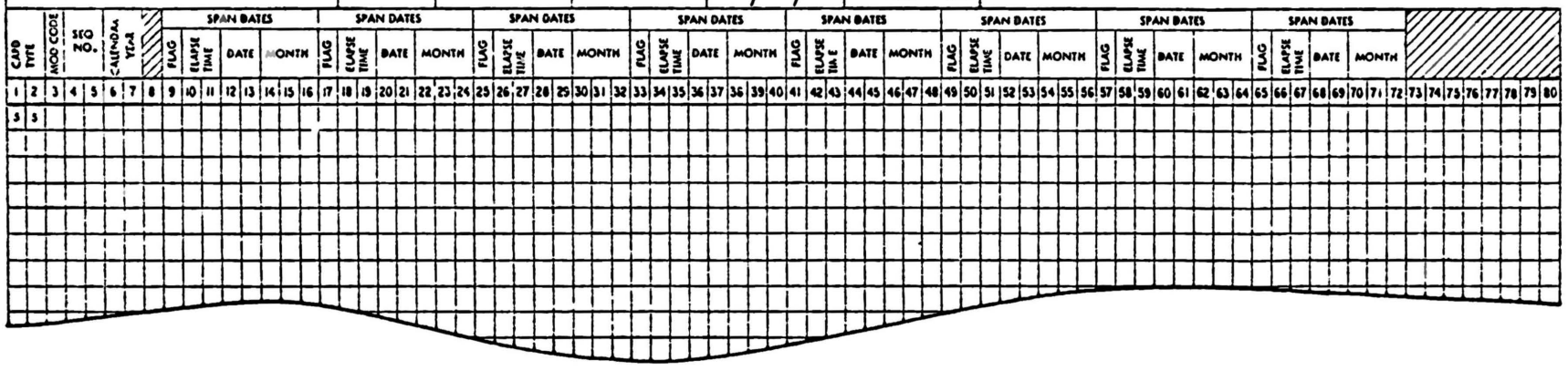


FIGURE 16. PMS/360 COST PROCESSOR STANDARD CALENDAR CARDS

IBM DATA SYSTEMS DIVISION
DEVELOPMENT LABORATORIES

ACCOUNTING CALENDAR CARD

NAME | DEP. | PHONE NO | PROBLEM NO. | DATE DUE OUT / / | SHEET ___ OF ___

| CARD TYPE | NON CODE | ACCTG YEAR | SPO NO | ACCTG CAL FLAG | ACCOUNTING PERIOD DATE FIELDS | | |

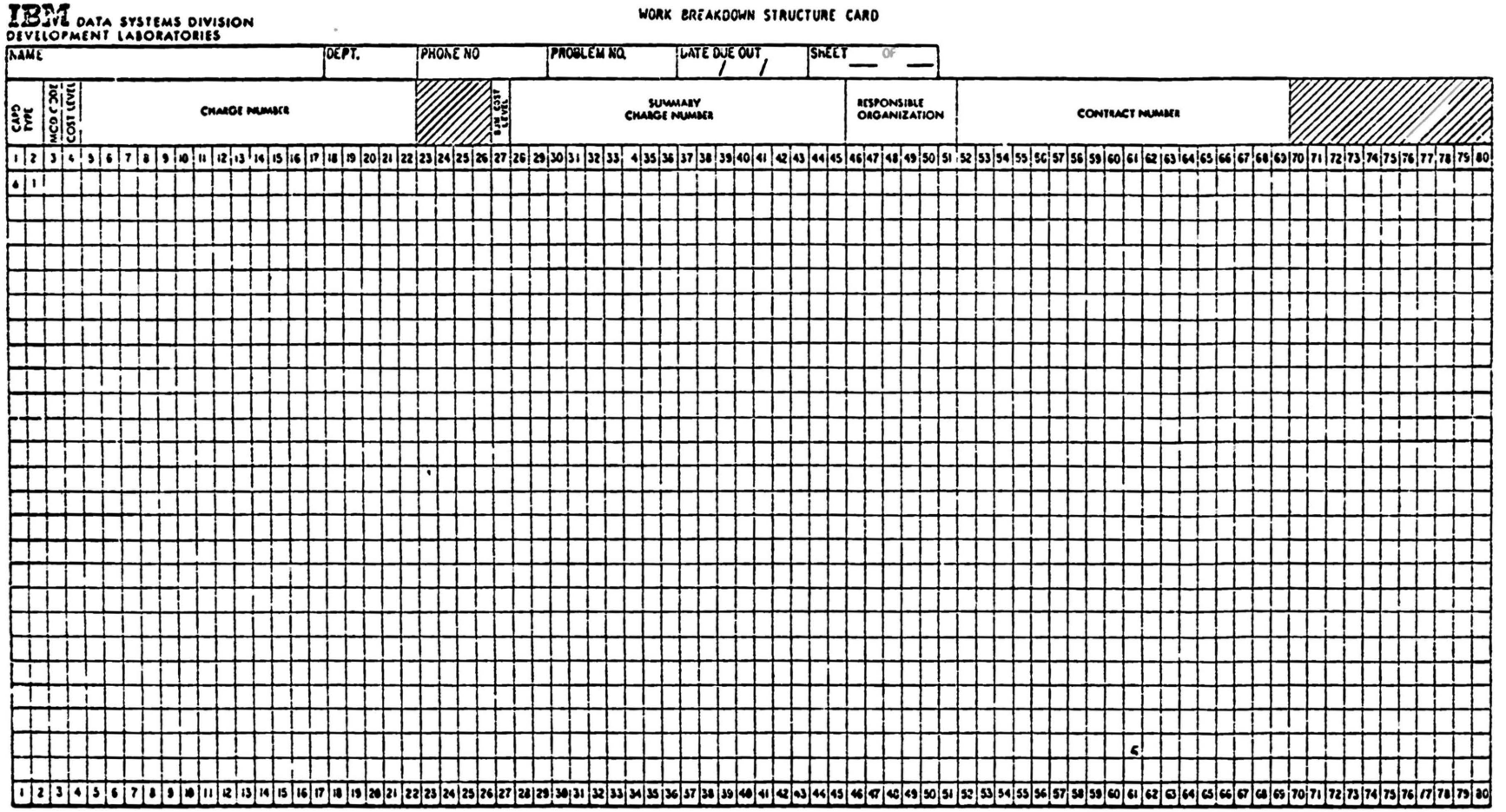


FIGURE 18. PMS/360 COST PROCESSOR WORK BREAKDOWN STRUCTURE CARD

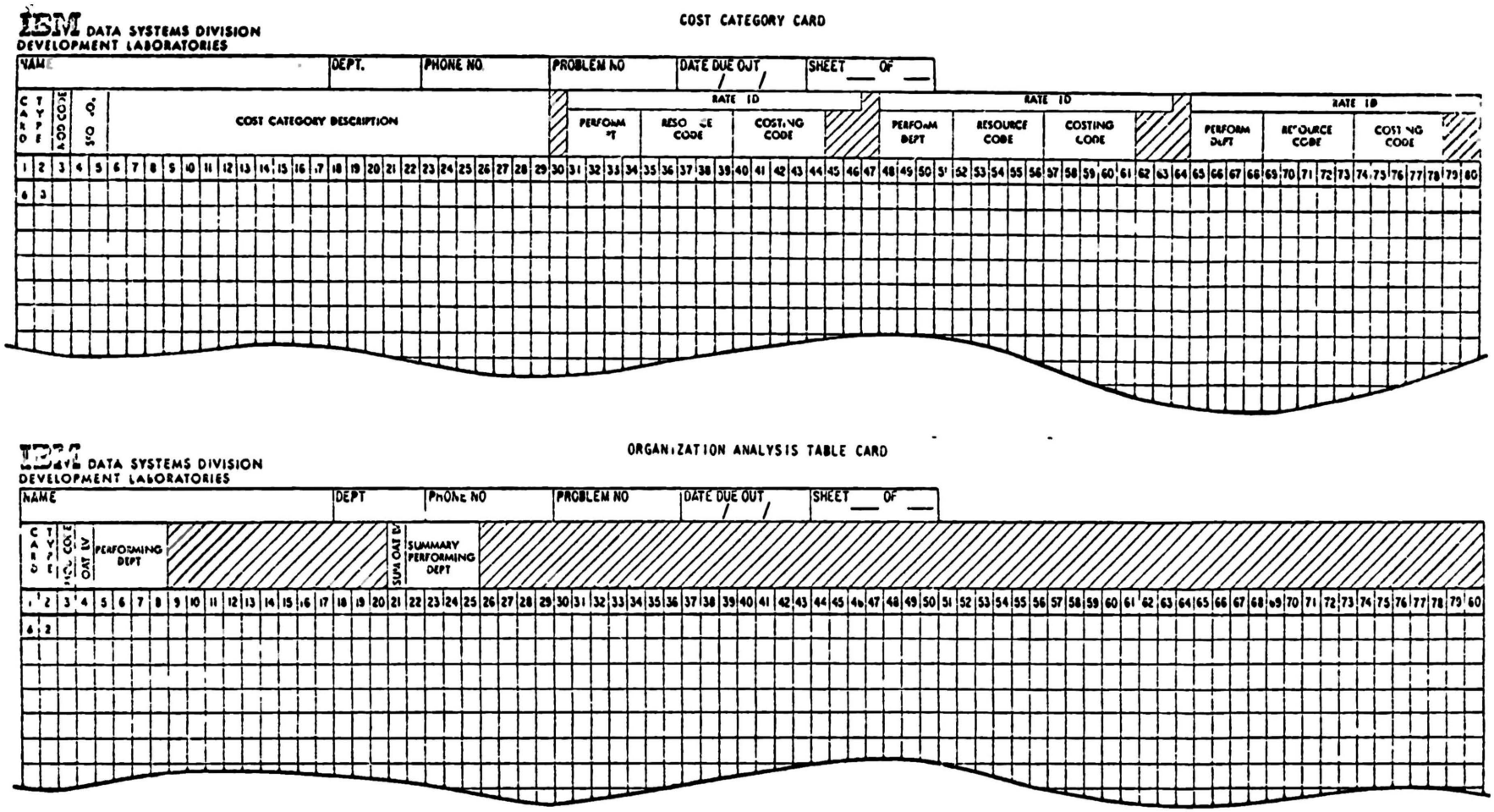
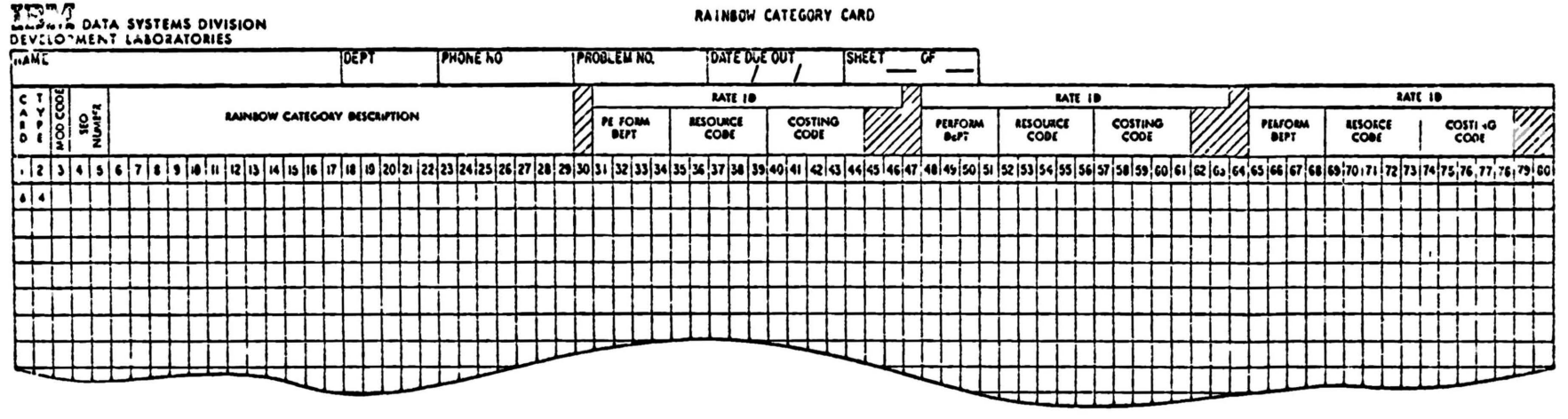


FIGURE 19. ORGANIZATION ANALYSIS TABLE & COST CATEGORY CARDS



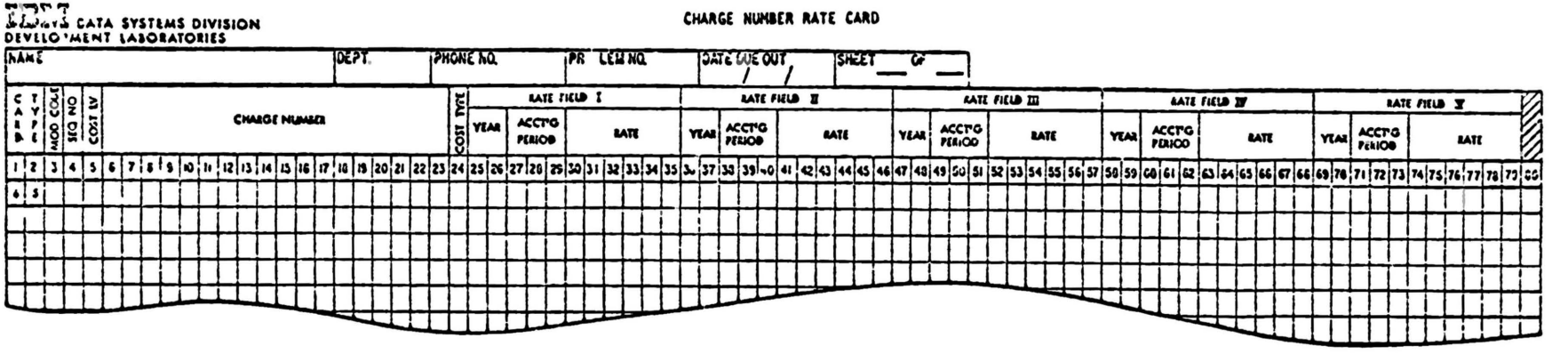


FIGURE 20. RAINBOW CATEGORY & CHARGE NUMBER RATE CARDS

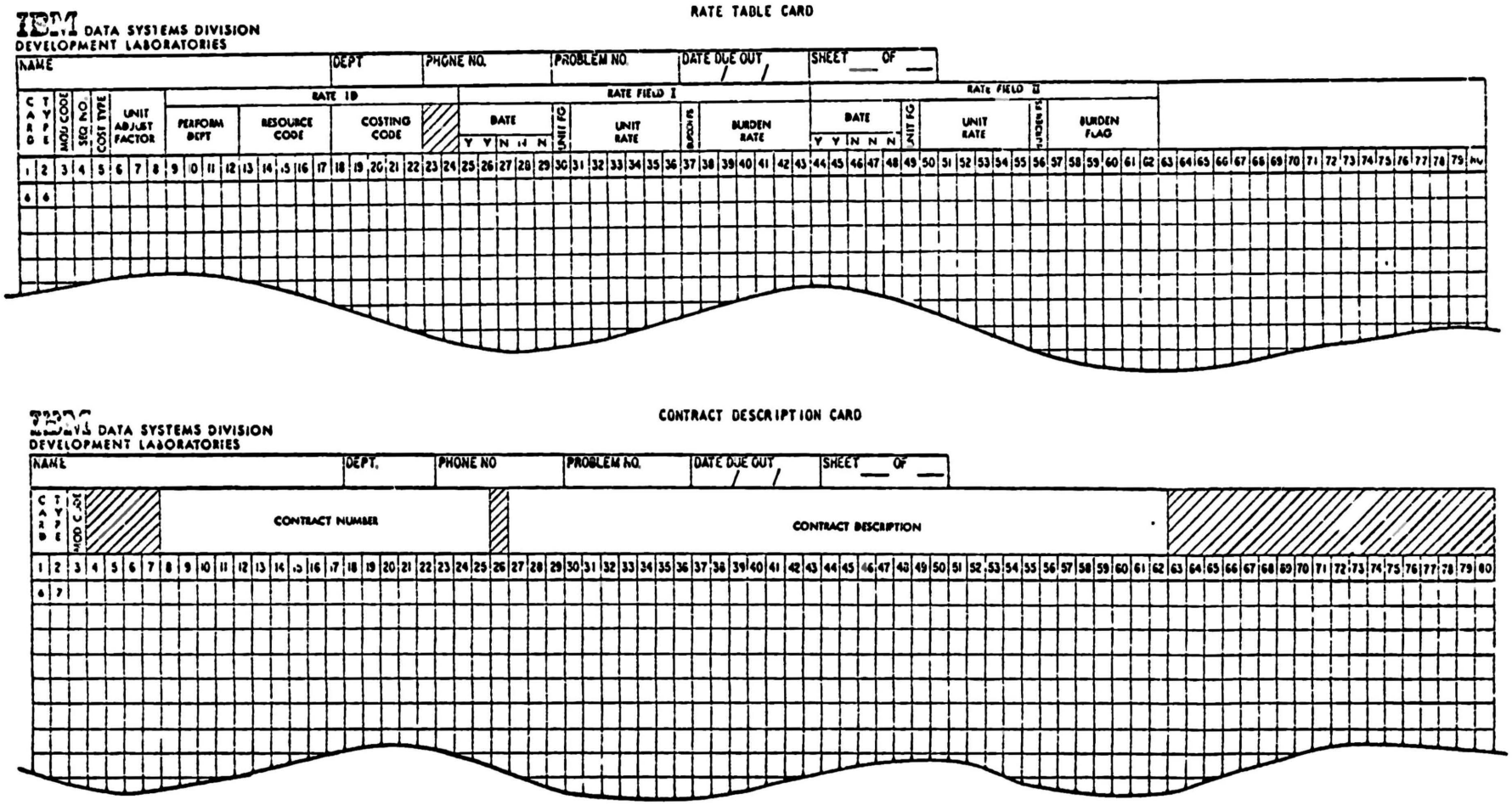
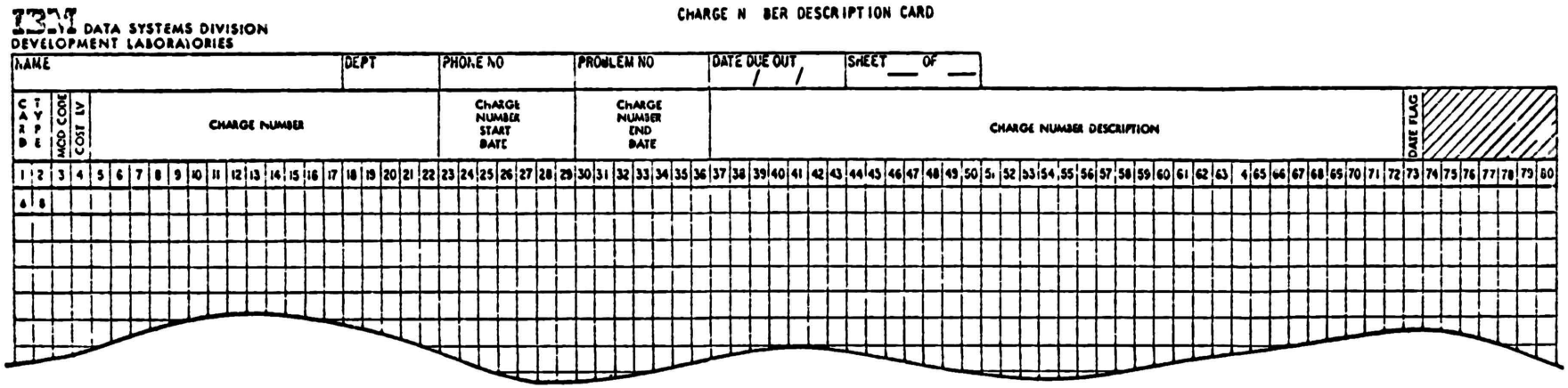


FIGURE 21. RATE TABLE & CONTRACT DESCRIPTION CARDS



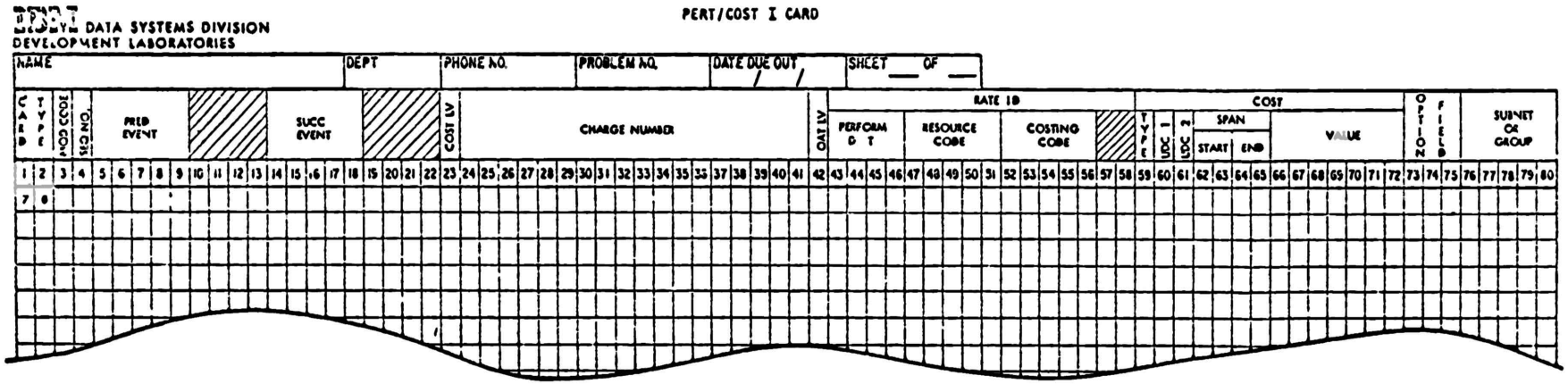


FIGURE 22. CHARGE NUMBER DESCRIPTION & PERT/COST I CARDS

IBM DATA SYSTEMS DIVISION
DEVELOPMENT LABORATORIES

PERT/COST ☐ CARD

NAME | DEPT | PHONE NO | PROBLEM NO. | DATE DUE OUT / / | SHEET __ OF __

CARD TYPE	MOD CODE	SEQ NO	EVENT	COST LV	CHARGE NUMBER	OAT LV	RATE ID: PERFORM DEPT	RESOURCE CODE	COSTING CODE	COST: TYPE	UDC 1	UDC 2	INCREMENT	VALUE	OPTION FIELD	SUBNET OR GROUP
1 2	3	4	5 6 7 8 9 10 11 12 13	14 15 16 17 18	19 20 21 22 23	24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41	42	43 44 45 46	47 48 49 50	51 52	53 54 55 56	57 58	59	60	61 62 63 64 65	66 67 68 69 70 71 72	73 74 75	76 77 78 79 80
7 1																		

IBM DATA SYSTEMS DIVISION
DEVELOPMENT LABORATORIES

COST MILESTONE CARD

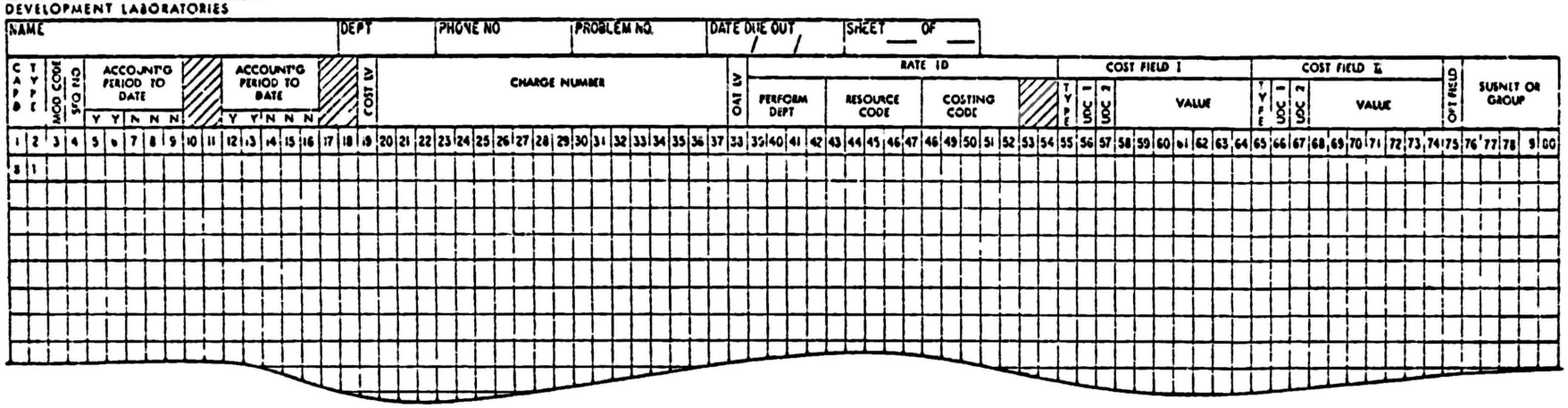
NAME | DEPT | PHONE NO | PROBLEM NO. | DATE DUE OUT / / | SHEET __ OF __

CARD TYPE	MOD CODE	SEQ NO	COST MILESTONE EVENT	COST LV	CHARGE NUMBER	OAT LV	RATE ID: PERFORM DEPT	RESOURCE CODE	COSTING CODE	SUBNET OR GROUP
1 2	3	4	5 6 7 8 9 10 11 12 13	14 15 16 17 18	19 20 21 22 23	24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41	42	43 44 45 46	47 48 49 50 51	52 53 54 55 56	57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75	76 77 78 79 80
7 2												

FIGURE 23. PERT/COST II & COST MILESTONE CARDS

IBM DATA SYSTEMS DIVISION
DEVELOPMENT LABORATORIES

COST-I CARD



IBM DATA SYSTEMS DIVISION
DEVELOPMENT LABORATORIES

COST-II CARD

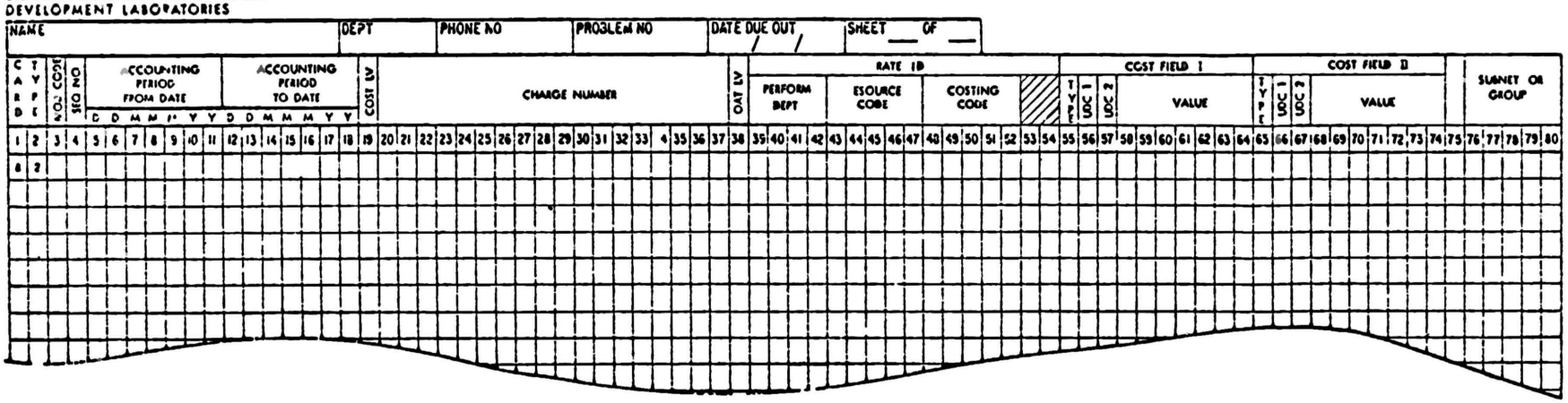


FIGURE 24. COST I & COST II CARDS

3. Report Processor

As stated previously, no reports are received from the Network or Cost Processor. It is the job of the Report Processor to generate the output reports. A set of standard output reports are available through the system and the reports may be modified to suit the specific needs of the user. In addition the Report Processor can be modified to produce new reports required by the user based on either the input data generated by the Network and Cost Processors or on independently generated user data. This last modification requires some knowledge of computer programming.

The output reports are produced by a set of procedures called in by control cards. Each procedure is identified on the control card by a name and one or more parameters that specify the information to be operated upon. The information on these control cards is compiled into machine language, which results in executing the requested report. Each report is assigned a number to be used in the Report Calling Procedure.

Below is an example of the procedure statements required for calling the Activity Time Status Report (REPORT 9). The report itself will be described later.

Statement	Code	Procedure	Parameters
1.	RP	BEGIN	
2.	RP	RIPTIME	
3.	RP	RIPLIST,	('NETWORK 1')
4.	RP	RIPFILE,	('INTFILE 3','ACPTFILE')
5.	RP	REPORT 09	
6.	RP	STOP	

Several reports can be called with one procedure list simply by adding statements following statement 5. These added statements simply give the report number of the report desired.

The procedure required for calling COST reports is of the same form as the example above with different procedure names.

The time reports which can be generated from the Network Processor are listed below with a description following. The first two are standard reports while the last one requires some special procedures for generation.

PERT/TIME REPORTS

1. Activity Time Status Report, sorted by:
    a. Predecessor-successor
    b. Successor-predecessor
    c. Slack (Critical Path list)
    d. Expected date
    e. Latest allowable date
    f. Department and expected date
    g. Department and latest date

This report is a listing of the acceptable activities in a PERT network or subnet. Each acceptable activity is printed on a seperate line containing the predecessor and successor events of the activity, its description, and time and schedule information as detailed below. The output may be sorted in any desired combination of the fields listed above. The numbers associated with the following field descriptions correspond to the encircled field numbers in the sample report shown in Figure 25.

(1) Program. The complete title of the network consisting of date, description, and network name.

(2) Project. The complete title of the subnet consisting of date, description, and subnet name.

(3) Run Date. The date of the computer run.

(4) Sorted By. The fields upon which the data in this report are sorted.

(5) Level. The time summary level of this report, consisting either of a digit between 1 and 9 or the word DETAIL.

(6) Pred. Event. The predecessor event number for the activity described.

(7) Succ. Event. The succeeding event number for the activity described.

(8) Type of Event. The letters S, E, or I to indicate whether the event is a start, end, or interface event.

(9) Cycle Code. The grouping for the activity being described.

(10) Activity Description. The description taken off the activity card of milestone event card.

(11) Time Estimate. The optimistic (A), most likely (M), and pessimistic (B) time estimates for the activity described.

(12) Slack. The primary and secondary slack of this activity, in the same units as the time estimate.

(13) Completion Dates. The expected and latest allowable dates for the successor event of this activity.

(14) Schedule Date. The scheduled completion date for the successor event of this activity.

(15) Department. The department name as entered in the

department field of the activity card or milestone event card.

2. Functional Bar Chart

This report generates a bar chart of the general type used by many contractors. The scale of the bar chart can be controlled by the user by specifying the units to be used on the ordinate and abscissa.

3. Milestone Status Report

This report presents schedule information for selected network events which represent major milestones of accomplishment toward completion of a report. A sample milestone report is shown in Figure 26. The following is a description of all items contained on the report.

(1) The designation of the total project that is identified with the reporting organization.

(2) Level/Summary Item. The number, description, and summary number of the summary item for which the report is being prepared.

(3) Reporting Organization. The name or identification of the organization responsible for the work.

(4) Contract Number. The numeric designation of the contract(s) included in each report.

(5) Report Dates. Term: The beginning and ending date for the total increment being covered in the report. Cut off date: The accounting cut off date for the period of the actual costs being reported. Release Date: The

ACTIVITY TIME STATUS REPORT

①PROGRAM 030CT66 BETA TEST PMS 360 NETWORK BETA RUN DATE 26JAN67③
PROJECT② 030CT66 DESIGN AND MANUFACTORING SUBNET SUB1

LEVEL DETAIL⑤ . SORTED BY SUCC.,PRED④

PRED.⑥ EVENT	SUCC.⑦ EVENT	⑧	CYCLE⑨ CODE	ACTIVITY⑩ DESCRIPTION	⑪ TIME ESTIMATES A	M	B	⑫ SLACK PRIMR	SECND	⑬ COMPLETION DATES EXPECTED	LATEST	⑭ SCHED. DATE	⑮ DEPT.
I1		I		INTERFACE FROM SUB1 TO SUB2				45.5	.0	21SEP67	14AUG68		
I2		I		INTERFACE FROM SUB1 TO SUB2				.0	.0	12JAN68	12JAN68		
I3		I		INTERFACE FROM SUB1 TO SUB2				60.5	.0	18JUL67	26SEP68		
I4		I		INTERFACE FROM SUB1 TO SUB2				12.5	.0	23AUG67	21NOV67		
23001		E		C MOTOR MANUFACTURING				.0	.0	02DEC68	02DEC68		
23021		E		1ST CUSTOMER ACCEPTANCE				.0	.0	09FEB68	09FEB68		
24030	I1		AA	INTERFACE FROM SUB1 TO SUB2	000.0			45.5	.0	21SEP67	14AUG68		
23020	I2		AA	INTERFACE FROM SUB1 TO SUB2	000.0			.0	.0	12JAN68	12JAN68		
22013	I3		AA	INTERFACE FROM SUB1 TO SUB2	000.0			60.5	.0	18JUL67	26SEP68		
20002	I4		BB	INTERFACE FROM SUB1 TO SUB2	000.0			12.5	.0	23AUG67	21NOV67		
	I5	I		INTERFACE TO SUB1 FROM SUB2				45.5	.0	A10JAN68	02DEC68		
	I6	I		INTERFACE TO SUB1 FROM SUB2				30.0	.0	A26APR68	02DEC68		
	I7	I		INTERFACE TO SUB1 FROM SUB2				60.5	.0	A21SEP67	02DEC68		
	I8	I		INTERFACE TO SUB1 FROM SUB2				57.5	.0	A12OCT67	02DEC68		
	START	S		MISSILE X CO				.0	.0	A03OCT66	03OCT66		
START	10000		AA	S CHAMBER ASSEMBLY DESIGN	000.0			.0	.0	03OCT66	03OCT66		
10000	10001		AA	C CHAMBER ASSEMBLY DESIGN	018.0			.0	.0	10FEB67	10FEB67		
10001	10002		AA	CHAMBER ASSEMBLY DESIGN APPROV	002.0			.0	.0	24FEB67	24FEB67		
I5	10003		CC	CHAMBER ASSEMBLY DESIGN FIRMED	000.0			45.5	.0	10JAN68	02DEC68		
10002	10003		AA	CHAMBER ASSEMBLY DESIGN FIRMED	020.0			60.5	.0	18JUL67	02DEC68		
10000	10010		AA	S ASSEMBLED MOTOR DESIGN	004.0			28.5	.0	01NOV66	23MAY67		
10020	10010		AA	S ASSEMBLED MOTOR DESIGN	004.0			28.5	.0	01NOV66	23MAY67		
10030	10010		AA	S ASSEMBLED MOTOR DESIGN	004.0			28.5	.0	01NOV66	23MAY67		
10010	10011		FF	C ASSEMBLED MOTOR DESIGN	022.0			28.5	.0	07APR67	31OCT67		
10011	10012		FF	ASSEMBLED MOTOR DESIGN APPROVE	003.0			28.5	.0	28APR67	21NOV67		
I6	10013		DD	ASSEMBLED MOTOR DESIGN FIRMED	000.0			30.0	.0	26APR68	02DEC68		
10012	10013		FF	ASSEMBLED MOTOR DESIGN FIRMED	020.0			60.5	.0	21SEP67	02DEC68		
START	10020		AA	S NOZZLE DESIGN	000.0			12.5	.0	03OCT66	03JAN67		
10020	10021		FF	C NOZZLE DESIGN	017.0			12.5	.0	03FEB67	02MAY67		
10021	10022		FF	NOZZLE DESIGN APPROVED	002.0			12.5	.0	17FEB67	16MAY67		
I8	10023		GG	NOZZLE DESIGN FIRMED	000.0			57.5	.0	12OCT67	02DEC68		
10022	10023		GG	NOZZLE DESIGN FIRMED	020.0			70.5	.0	11JUL67	02DEC68		
START	10030		AA	S IGNITER DESIGN	000.0			28.5	.0	03OCT66	25APR67		
10030	10031		BB	C IGNITER DESIGN	012.0			37.0	.0	29DEC66	21SEP67		
10031	10032		BB	IGNITER DESIGN APPROVED	002.0			37.0	.0	13JAN67	05OCT67		
I7	10033		CC	IGNITER DESIGN FIRMED	000.0			60.5	.0	21SEP67	02DEC68		
10032	10033		BB	IGNITER DESIGN FIRMED	015.0			80.5	.0	26APR67	02DEC68		
10022	20000		GG	S NOZZLE PURCHASE	001.0			12.5	.0	24FEB67	23MAY67		
	20001	S		NOZZLE MASTER TOOL GAGE ON DOC				19.5	.0	A03JUL67	21NOV67		
20000	20002		GG	1ST NOZZLE ON DOCK	025.0			12.5	.0	23AUG67	21NOV67		
20001	20002		GG	1ST NOZZLE ON DOCK	000.0			19.5	.0	03JUL67	21NOV67		
10023	20003		BB	C NOZZLE PURCHASE	000.0			57.5	.0	12OCT67	02DEC68		
20002	20003		BB	C NOZZLE PURCHASE	030.0			34.5	.0	27MAR68	02DEC68		
10032	22000		BB	S IGNITER PURCHASE	001.0			37.0	.0	20JAN67	12OCT67		
22000	22001		AA	1ST IGNITER GRAIN ON DOCK	011.0			37.0	.0	07APR67	03JAN68		
22001	22002		AA	S IGNITER CASTING	000.0			37.0	.0	07APR67	03JAN68		

FIGURE 25. ACTIVITY TIME STATUS REPORT

PERT
MILESTONE REPORT

(1)	REPORTING ORGN. (3)	CONTRACT NO. (4)	REPORT DATES (5)
LEVEL/SUMMARY ITEM: (2)			TERM (SPAN): CUT OFF DATE: RELEASE DATE:

MILESTONE DESCRIPTION (6)	SLACK (7)	DATE (8)	SCHEDULE (9)	REMARKS (11)
			S-SCHED COMPL DATE E-EARLIEST COMPL DATE L-LATEST COMPL DATE A-ACTUAL COMPL DATE M-EARLIEST COMPL DATE AFTER MGMT ACTION P YR 1963 J F M A M J J A S O N D (10) 1964 J F M A M J J A S O N D 65 66 67 68 L YR	
12000685 APPROVE ELEC DSGN SPEC MOD ONE	2.1	05JUN63 20MAY63 05JUN63	S E L	
12000687 APPROVE ELEC DSGN SPEC MOD TWO	2.1	20JUN63 05JUN63 20JUN63	S E L	
12001999 COMPLETE SPECIAL TEST EQUIPMENT	-7.2	22OCT63 01SEP63 22OCT63 20 OCT 63	S E L M	
12000391 COMPLETE INSTRUMENTATION PROTO PERT	0.0	22DEC63 22DEC63 22DEC63	S E L	ITEM 22322 SCHEDULED COMPLETE 10 Jan 64

TIME NOW

FIGURE 26. PERT MILESTONE REPORT

date that the report is to be released to management.

(6) Milestone Description. The network event numbers and nomenclature which are selected as milestones.

(7) Slack. The slack associated with the network milestone event.

(8) Date. The day, month, and year of the "S", "A", "E", "L", or "M" positions.

(9) Schedule Calendar. A calendar time reference for display of schedule completions.

(10) Schedule Completions. The scheduled "S", actual "A", earliest "E", and latest "L" completion dates for the network milestone events.

PERT/COST REPORTS

The following Cost Reports can be produced. The first four are standard reports of the Report Processor. The remainder of the reports require special procedures. Any other cost reports that might be desired by the user can be generated but some programming is necessary.

1. Management Summary Report

This report presents the current and projected schedule and financial status of the total project and each of the major items or tasks within the project. Composite cost and schedule information is shown at several levels of the Work Breakdown Structure, based on the corresponding charge number structure set up in the Work Breakdown Structure. A sample report is shown in Figure 27. The field descriptions below are keyed to

the encircled numbers on the illustrated report.

(1) Contract Description. The designation of the total project identified with the reporting organization.

(2) Level/Summary Item. The cost level, description, and summary number of the item for which the report is being prepared.

(3) Reporting Organization. The name of the organization responsible for reporting the work.

(4) Contract Number. The alphameric designation of the contract.

(5) Report Dates. Includes the term, "cut-off" dates and release date previously described.

(6) Item. The charge number, level, and description for each summary item on which information is presented.

(7) Cost of Work $. Dollars data is presented here after being sealed.

(8) Work Performed to Date. Cost reported from the starting date through the "as of" date. Includes fields (9), (10), and (11).

(9) Value. The total planned cost for the work performed within the summary item (charge number).

(10) Actual Cost. The actual dollar expenditures charged against the summary item or a detail charge number.

(11) (Overrun) Underrun. The value (9) minus the actual cost (10) of the work performed to date.

(12) Totals at Completion. Includes fields (13), (14), and (15) and covers the entire time span of the project.

MANAGEMENT SUMMARY REPORT PAGE 2

(1) CONTRACT DESCRIPTION * (3) REPORTING ORGN. * (4) CONTRACT NO. * REPORT DATES

CONTRACT DESCRIPTION 111111111111111* CONTRACT NUMBER 11 *TERM (SPAN)-
*CUT OFF DATE- 10FEB67 (5)
LEVEL/SUMMARY ITEM- 1CHARGE NUMBER DESCRIPTION OF L1C1 --L1C1 *RELEASE DATE- 13DEC66

(6) ITEM	COST OF WORK $/10 (7) — WORK PERFORMED TO DATE (8)			TOTALS AT COMPLETION (12)			(16)	(17) SCHEDULE		
	(9) VALUE	(10) ACTUAL COST	(11) (OVERRUN) UNDERRUN	(13) PLANNED COST	(14) LATEST REV EST	(15) PROJECTED (OVERRUN) UNDERRUN	MOST CRIT SLACK UNITS	COMPL DATE	PI YI	1967 JFMAMJJASOND / 1968 JFMAMJJASOND / 9012IL IY
CHARGE NUMBER DESCRIPTION OF L1C1 --								28FEB69	I	S I
LEV 1			0.97			0.96		03JAN66	EI	I
L1C1	145,529	3,246	142,283	146,284	4,765	141,519	.0	03JAN66	LI	I
CHARGE NUMBER DESCRIPTION OF L2C1 --								28FEB69	I	S I
LEV 2			0.98			0.98		03JAN66	EI	I
L2C1	145,529	1,623	143,906	146,096	2,357	143,739		03JAN66	LI	I
CHARGE NUMBER DESCRIPTION OF L2C2 --								03JAN66	XI	I
LEV 2								03JAN66	EI	I
L2C2	0	0	0	0	0	0	.0	03JAN66	LI	I

TIME NOW

FIGURE 27. MANAGEMENT SUMMARY REPORT

(13) Planned Cost. The approved dollar budget for the charge number reported.

(14) Latest revised Estimate. The latest estimate, or anticipated final cost for the charge number or summary item reported.

(15) Projected (Overrun) Underrun. The planned cost (13) minus the latest revised estimate (14).

(16) Most Critical Slack. The greatest negative or minimum positive slack in time estimating units with respect to the end points of the PERT Time activities tied to the charge number or summary number.

(17) Completion Dates. The day, month, and year of the "S", "A", "E", and "L" positions shown in the schedule graph (18).

(18) Schedule (graph). This is a display showing the month or year in which the expected, latest, and scheduled completion dates fall.

2. Financial Plan and Status Report

This report presents an accounting-period-by-accounting-period comparison at any desired level of actual cost or latest revised estimate against planned cost. It serves as a financial monitoring tool. Prior cumulative cost as well as future total cost are shown for each charge number at the requested level. A sample report is shown in F'gure 28 to illustrate the following description.

(1-5) Same as corresponding numbers on the Management

Summary report (Page 51).

(6) Accounting Period. Costs for the accounting period prior to the report "as of" date are summed and printed on the top data line, designated as "PRIOR".

(7) Charge Number. All detail level charge numbers that accumulate into the summary charge number on which the report is drawn.

(8) Incremental Cost. Total dollar costs for the designated accounting period.

(9) Actual. The actual dollar expenditures accumulated against the charge number.

(10) Planned. The dollar budget for the indicated charge number and time period.

(11) Latest Revised Estimate. The latest estimate of cost for the indicated charge number and t' e period.

(12) (Over) Under Plan. The planned cost (10) minus the latest revised estimate (11), for the incremental cost and charge number shown.

(13) Cumulative Cost. These columns report total dollars accumulated against the indicated charge number from the start date of the network to the date in the accounting period column (6).

(14) Actual. The actual dollar expenditures accumulated against the charge number, from the beginning of the program or project to the end of the indicated accounting period.

(15) Planned. The dollar budget for the charge number

FINANCIAL PLAN AND STATUS
BY ACCOUNTING PERIOD, BY CHARGE NUMBER

PAGE 1

CONTRACT DESCRIPTION (1) | REPORTING ORGN. (3) | CONTRACT NO. (4) | REPORT DATES (5)

ITERM (SPAN)-
(2) LEVEL/SUMMARY ITEM- 1/DUMMY LEVEL 1 | CUT OFF DATE- 10FEB67 | RELEASE DATE- 09DEC66

(6) ACCT'G PERIOD	(7) CHARGE NUMBER		INCREMENTAL COST (9) ACTUAL	(10) PLANNED	LATEST REVISED EST. (11)	(OVER) UNDER PLAN (12)	CUMULATIVE COST (13) (14) ACTUAL	(15) PLANNED	LATEST REVISED EST. (16)	(OVER) UNDER PLAN (17)	REMARKS
PRIOR	L2C5		139	17	139	(121)	139	17	139	(121)	
	L3C6		4	1	4	(3)	4	1	4	(3)	
	L8C5		0	0	0	0	0	0	0	0	
		TOTAL	143	18	143	(125)	143	18	143	(125)	
16/66	L3C6		5	2	10	(8)	9	3	14	(12)	
		TOTAL	5	2	10	(8)	148	20	153	(133)	
17/66	L3C6		0	1	10	(9)	9	4	24	(21)	
	L7C2		0	0	0	0	0	0	0	0	
		TOTAL	0	1	10	(9)	148	21	163	(142)	
1/67	L3C6		0	0	2	(2)	9	4	26	(22)	
	L7C2		0	0	0	0	0	0	0	0	
	L9C7		0	0	0	0	0	0	0	0	
		TOTAL	0	0	2	(2)	148	21	165	(144)	
2/67	L3C6		0	1	3	(3)	9	5	29	(25)	
	L7C2		0	0	0	0	0	0	0	0	
		TOTAL	0	1	3	(3)	148	27	168	(146)	
3/67	L3C6		0	0	0	0	9	5	29	(25)	
	L7C2		0	0	0	0	0	0	0	0	
		TOTAL	0	0	0	0	148	22	168	(146)	

FIGURE 28. FINANCIAL PLAN & STATUS REPORT

reported, from the beginning of the program or project to the end of the indicated accounting period.

(16) Latest Revised Estimate. The latest estimate of cost during the period from the beginning of the program or project to the end of the indicated accounting period.

(17) (Over) Under Plan. The planned cost (15) minus the latest revised estimate (16), for the cumulative cost and charge numbers shown.

3. Manpower Loading Report.

This report shows the type and quantity of manpower required month by month for the work covered by all detail level charge numbers that accumulate into the summary charge numbers at the specified summary level. A sample report is shown in Figure 29 to illustrate the following description.

(1-5) Same as corresponding numbers on the Management Summary Report (Page 51).

(6) Accounting Period. Man-hours for the accounting period prior to the report "as of" date are summed and printed on a line designated as PRIOR.

(7) Resource (Skill) Code. The code for the particular manpower skill or material type, for man-hours requested.

(8) Performing Organization. The department or organization that performs the work on the charge number reported.

(9) Charge Number. All detail charge numbers that accumulate into the summary charge on which this report is drawn.

MANPOWER LOADING REPORT PAGE 13

BY RES.,PERIOD,PERF.DEPT,CHARGE NO.

CONTRACT DESCRIPTION (1) | REPORTING ORGN (3) | CONTRACT NO. (4) | REPORT DATES (5)

CONTRACT DESCRIPTION 111111111111111 | CONTRACT NUMBER 11 | TERM (SPAN) -
CUT OFF DATE - 10FEB67
(2) LEVEL/SUMMARY ITEM- ▲/CHARGE NUMBER DESCRIPTION OF L1C1 -- L1C1 | RELEASE DATE - 12DEC66

IDENTIFICATION				MANHOURS				TIME	
(6) ACCOUNTING PERIOD	(7) RES. CODE	(8) PERF DEPT	(9) CHARGE NUMBER	(11) ACTUAL	(12) BUDGET	LATEST (13) REVISED ESTIMATE	(OVER) (14) UNDER PLAN	MOST (15) CRIT. SLACK	REMARKS
	AA								
1/66		L4D3	L1C1	29	2,200	0	(29)		
			L4C2	2	0	0	(2)		
	TOTAL			31	2,200	0	(31)		
2/66		L4D3	L1C1	88	2,000	0	(88)		
			L4C2	8	0	0	(8)		
		L6D3	L5C3	200	0	0	(200)		
	TOTAL			296	2,000	0	(296)		
3/66		L4D3	L1C1	103	1,600	0	(103)		
			L4C2	10	0	0	(10)		
		L6D3	L5C3	160	0	0	(160)		
	TOTAL			273	1,600	0	(273)		
4/66		L4D3	L1C1	103	1,600	0	(103)		
		L6D3	L5C3	160	0	0	(160)		
	TOTAL			263	1,600	0	(263)		
5/66		L4D3	L1C1	77	2,000	0	(77)		
		L6D3	L5C3	200	0	0	(200)		
	TOTAL			277	2,000	0	(277)		
6/66		L6D3	L5C3	200	0	0	(200)		
	TOTAL			200	0	0	(200)		
7/66		L6D3	L5C3	240	0	0	(240)		
	TOTAL			240	0	0	(240)		

FIGURE 29. MANPOWER LOADING REPORT

(10) Man Hours. Manpower data entered into the program are reported here in terms of man-hours only.

(11) Actual. The actual man-hours accumulated against the charge number in the period reported.

(12) Budget. The man-hours budgeted for the indicated charge number and time period.

(13) Latest Revised Estimate. The latest estimate of total man-hours for the indicated charge number and accounting period.

(14) (Over) Under Plan. Th planned man-hours (12) minus the latest revised estimate (13), for the data reported on this line.

(15) Most Critical Slack. The greatest negative or minimum positive slack in time estimating units with respect to the end points of the various PERT/Time activities tied to the charge number.

4. Program Outlook Graph

This graph displays budget, actual, and outlook cost data against time. A sample report is included in Figure 30 to illustrate the discussion.

(1) Project Description. The subnet description and name for the report.

(2) Run Date. The date of the computer run.

(3) "As-of" Date. The date of the data.

(4) Dollars. This is the abscissa of the graph showing dollars versus time.

(5) Accounting Period. The ordinate or time axis of the

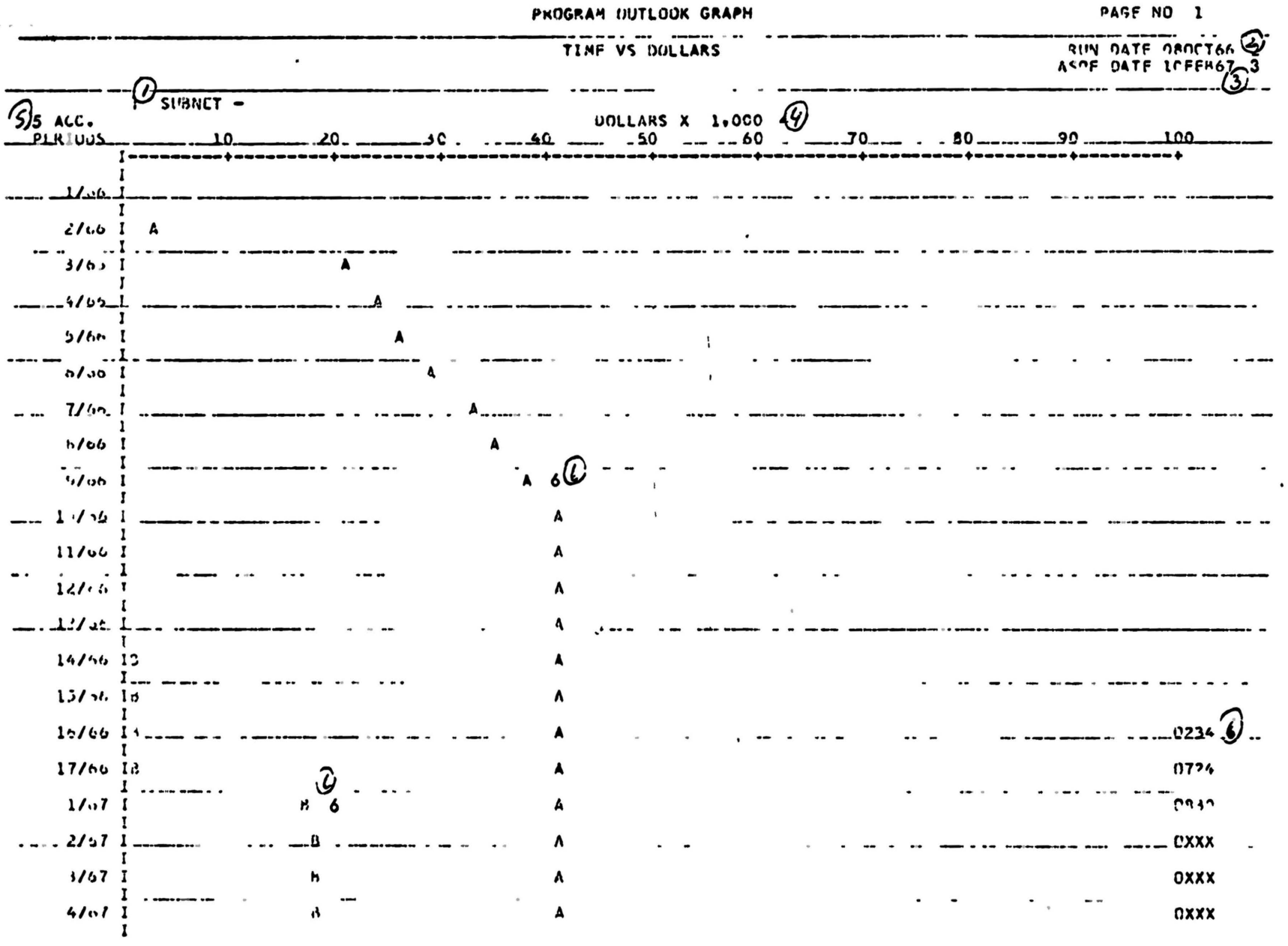


FIGURE 30. PROGRAM OUTLOOK GRAPH

graph. The time span of the graph is the duration of the project.

(6) Data Plots. These are curves of budget (B), actual (A), and outlook (O) data.

5. Program/Project Status Report

This report is a comprehensive output report. It is organized to reflect the end item work breakdown structure and provides time and cost information from the work package level up to the top of the project. This report contains information similar to the Management Summary Report but where the Management Summary Report provides information for a manager, this report shows more detail and is more easily analyzed. Information to be sorted may be arranged according to the Work Breakdown Structure, work packages by charge number, only completed work, in progress work, or future work. A sample report is shown in Figure 31. The following is a description of the keyed items on the sample report.

(1-5) Same as corresponding numbers on the Management Summary Report (Page 51).

(6) Charge or Summary Number. The description and charge or summary number of each work package or summary item for which time and cost information are presented in the report.

(7) Level. The number of the level on the Work Breakdown Structure at which the charge or summary numbers appears.

(8) First Event Number. The number of the first event in time for the work package or summary item.

(9) Last Event Number. The number of the last event in time

for the work package or summary item.

(10) Scheduled or Actual Completion Date. The calendar date on which all the work contained in the work package or summary item is scheduled for completion or was actually completed.

(11) Earliest and Latest Completion Dates. The earliest calendar date on which the work package or summary item can be completed and the latest date on which the work package or summary item can be scheduled for completion without delaying the completion of the project.

(12) Most Critical Slack. The worst slack with respect to the designated project end points, in weeks, for any of the activities within the work package or summary item.

(13) Value. The total planned cost for work performed within the summary item or work package.

(14) Actual Cost. The actual expenditures incurred plus any prespecified types of unliquidated commitments charged or assigned to a work package.

(15) (Overrun) Underrun. The value (13) for the work performed to date minus the actual cost (14) for the same work.

(16) Planned Cost. The approved planned cost for the total work package.

(17) Latest Revised Estimate. The latest estimate of cost for the total work package. This estimate is the sum of actual costs plus estimates to complete for each work package. For summary items, the appropriate work

PERT COST
PROGRAM/PROJECT STATUS REPORT

(1)	REPORTING ORGN. (3)	CONTRACT NO. (4)	REPORT DATES (5)
LEVEL/SUMMARY ITEM: (2)			TERM (SPAN): CUT OFF DATE: RELEASE DATE:

IDENTIFICATION				TIME STATUS			COST OF WORK $(000)					
							WORK PERFORMED TO DATE			TOTALS AT COMPLETION		
CHARGE OR SUMMARY NUMBER	LEVEL	FIRST EVENT NO.	LAST EVENT NO.	SCHED OR ACT (A) COMPL DATE	EARLI ST & LATEST COMPL DATE	MOST CRIT SLACK (WKS)	VALUE	ACTUAL COST	(OVERRUN) UNDERRUN	PLANNED COST	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN
(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
					NUMBER OF DIGITS							
18	2	9	9	8	8	9	7	7	9	7	7	9
xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxx	xx xx	xxxxxxxxxx xxxxxxxxx	xxxxxxxxxx xxxxxxxxx	xxxxxxxx	xxxxxxxx xxxxxxxx	-xx.x xxxxxxxxx	xxx,xxx	xxx,xxx	(.xx) (xxx,xxx)	xxx,xxx	xxx,xxx	(.xx) (xxx,xxx)
					DATA SPACES	109 10 119						

FIGURE 31. PROGRAM/PROJECT STATUS REPORT

package data is summed.

(18) Projected (Overrun) Underrun. The Planned Cost (16) minus the Latest Revised Estimate (17).

6. Organization Status Report

This report provides the operating level managers with detailed information breakdowns from the available store of data in the PERT/COST computer program. The data can be sorted by Responsible Organization, Performing Organization, or Resource Code. A sample report is shown in Figure 32 to illustrate the following description.

(1-5) Same as the corresponding numbers on the Management Summary Report (Page 51).

(6) Charge Number. The description and charge number for each work package for which time and cost information are presented in the report.

(7) Responsible Organization. The contractor's organization responsible for management of the work package.

(8) Performing Organization. The contractor's department or organization which will perform work on the work package.

(9) Resource Code. The contractors code for a particular man-power skill or material type.

(10) Actual Man-hours. The actual man-hour expenditures assigned to a work package.

(11) Planned Man-hours. The approved planned man-hours for the work package.

(12) Latest Revised Estimate. The latest estimate of man-hours for the work package. This is the sum of actual man-hour expenditures plus estimates to complete.

PERT COST
ORGANIZATION STATUS REPORT

①	REPORTING ORGN. ③	CONTRACT NO. ④	REPORT DATES TERM (SPAN): CUT OFF DATE: ⑤ RELEASE DATE:
LEVEL/SUMMARY ITEM: ②			

IDENTIFICATION				MANHOURS				DIRECT COSTS $(000)				TIME	
				WORK TO DATE	TOTALS AT COMPLETION			WORK TO DATE	TOTALS AT COMPLETION				
CHARGE NUMBER	RESP ORGN	PERF ORGN	RES CODE	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	MOST CRIT SLACK (WKS)	SCHED OR ACT (A) COMPL DATE
⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	⑰	⑱	⑲
						NUMBER OF DIGITS							
18	6	6	4	7	7	7	9	7	7	7	9	5	8
xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxx	xxxxxx xxxxxx	xxxxxx xxxxxx	xxxx xxxx	xxx,xxx	xxx,xxx	xxx,xxx	(.xx) (xxx,xxx)	xxx,xxx	xxx,xxx	xxx,xxx	(.xx) (xxx,xxx)	-xx.x	xxxxxx
				DATA SPACES		107 12 119							

FIGURE 32. ORGANIZATION STATUS REPORT

(13) Projected (Overrun) Underrun. The Planned man-hours (11) minus the latest Revised Estimate (12).

(14-17) Direct Costs.

(14) Actual Cost. The actual expenditures incurred plus any prespecified types of unliquidated commitments charged to a work package.

(15) Planned Cost. The approved planned cost for the work package.

(16) Latest Revised Estimate. The latest estimate of cost for the work package.

(17) Projected (Underrun) Overrun. The Planned Cost (15) minus the Latest Revised Estimate (16).

(18) Most Critical Slack. The worst slack with respect to designated project end points for any activity within a work package.

(19) Scheduled (S) or Actual (A) Completion Date. The calendar date on which all the work contained in the work package is scheduled for completion or was actually completed. The scheduled completion date is one established by management otherwise this field is blank.

7. Cost Category Report

This report presents a grouping of functional, hardware, or other significant cost elements in specified categories for reporting purposes. These categories are established by relating work packages or elements of cost within work packages to the specified categories. No distortion of the work breakdown structure is required to segregate this data. A sample report is shown in

Figure 33 to illustrate the following discussion.

(1-5) Same as corresponding numbers on the Management Summary Report (Page 51).

(6) Cost Category. The name and/or number of a functional, hardware, or other significant cost category for which costs are to be summarized.

(7) Planned Man-hours. The approved planned man-hours assigned all work packages identified with the indicated Cost Category (6) from the beginning to the Term (5) to the Cut-Off Date (5).

(8) Actual Man-hours. The actual man-hour expenditures incurred, charged, or assigned to all work packages identified with the indicated Cost Category (6).

(9) Planned Man-hours. (Totals at Completion). The approved planned man-hours assigned to all work packages identified with the indicated Cost Category (6).

(10) Latest Revised Estimate (Totals at Completion). The latest revised estimate of man-hours for all the work packages identified with the indicated Cost Category (6).

(11) Projected (Overrun) Underrun. The Planned Man-hours (9) minus the Latest Revised Estimate (10).

(12-16) Total Cost.

(12) Planned. The approved planned cost assigned to all work packages identified with the indicated Cost Category (6).

(13) Actual. The actual expenditures incurred plus any pre-specified commitments charged or assigned to work packages identified with the indicated Cost category (6).

(14) Planned Cost (Totals at Completion). The approved planned cost assigned to all work packages identified with the indicated Cost Category (6).

(15) Latest Revised Estimate (Totals at Completion). The latest revised estimate of cost for all the work packages identified with the indicated Cost Category (6).

(16) Projected (Overrun) Underrun. The Planned Cost (14) minus the Latest Revised Estimate (15).

PERT COST
COST CATEGORY STATUS REPORT

(1)	REPORTING ORGN. (3)	CONTRACT NO. (4)	REPORT DATES
LEVEL SUMMARY ITEM: (2)			TERM (SPAN): CUT OFF DATE: (5) RELEASE DATE:

IDENTIFICATION	MANHOURS					TOTAL COST $(000)				
	TO DATE		TOTALS AT COMPLETION			WORK TO DATE		TOTALS AT COMPLETION		
COST CATEGORY	PLANNED	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	PLANNED	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN
(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
			NUMBER OF DIGITS							
18	11	11	11	11	9	7	7	7	7	9
xxxxxxxxxxxxxxxxxx	xxxxxxxxxxx xxx,xxx,xxx	xxxxxxxxxxx xxx,xxx,xxx	xxxxxxxxxxx xxx,xxx,xxx	xxxxxxxxxxx xxx,xxx,xxx	(.xx) (xxx,xxx	xxx,xxx	xxx,xxx	xxx,xxx	xxx,xxx	(.xx) (xxx,xxx
			DATA SPACES 108 11 119							

FIGURE 33. COST CATEGORY REPORT

III. INVESTIGATION OF CONTRACTOR METHODS

A. General

In order to show the advantages or disadvantages of the Project Management System/360, the methods of three different contractors were investigated. These methods will be used as a basis of comparison between what might represent the conventional contractors methods of time and cost control and the control methods included in the PMS-360 system.

The following is a discussion of the information sought in the investigation of the contractor's methods of time and cost control from the time at which the estimate is made until the construction of the project is completed.

The estimate prepared by the contractor is one of the most important parts of his business. The estimate can determine the success of his company, therefore, it is necessary that he have a sound estimating procedure.

The estimate of material cost will most probably follow the standard method of a detailed material take-off which is then priced by item to arrive at a total material cost. The estimate of labor cost, however, may be arrived at by different methods. The estimate may be based on historical data, published references or on the personal experience of the estimator. Another point which may vary is the level of detail arrived at in expressing the estimate. The estimate can also vary according to the amount of investigation of alternate methods of doing work items with the possibility of new methods or sequences of operation reducing the time required to complete the project.

The overhead on the job is also an important factor in the estimating. How does the contractor estimate overhead? Is it estimated by each individual item of overhead cost or simply included as a percentage of either total job cost or labor cost?

Another item of importance is the scheduling of the job. The contractor may be required to meet a specific completion date. How does he go about controlling the time element of the project in order to meet the specified completion date? Does he use his own experience in order to determine how he is progressing with reference to time or does he use some more technical method such as scheduling by Critical Path Method or PERT? This time control can be a very important influence on the cost of the job especially if a liquidated damages clause is included in the contract.

Now let us assume that the contractor has submitted the low bid and the contract agreements have been signed. The contractor is now committed to a cost and time limit. How does he go about making sure that he meets these commitments? There are a number of factors that must be considered in the contractor's on-the-job time and cost control. Among these are availability of resources; both manpower and material, and the manner in which he keeps records of the material cost incurred, labor cost incurred, and where he stands as far as cost and time consumed at any p int in the job compared with what should have been consumed to date according to the estimated time and cost values.

The matter of resources can be a strong influence on the progress of the job. The contractor needs some assurance of the availability of both manpower and material. Does the contractor have a reliable

method of determining how much manpower of each working trade will be required at any point during the job or does he have to assign workers on a week to week or perhaps even a day to day basis? Does he have any method of leveling his manpower requirements in order to keep an almost constant crew working or does he have to hire and lay off periodically?

It is very important that material be ordered far enough ahead o time to assure delivery by the time it is needed on the job. If delivery is late, it may in many cases delay some portion of the project or even the entire project if it happens to be a critical item. Can the contractor pinpoint a day or a week in which he is going to need any particular item of material or does he have to approximate when the material will be needed?

The records kept on the job of cost and time are an important part of the contractor's control of the job. What type of records are kept and how detailed or accurate are they? Do labor records show only the number of hours spent on the project or is the manpower properly distributed among the many seperate activities of the job? In order to determine if material costs compare with estimated costs, the contractor needs to keep an accurate material cost record. Does the contractor's material cost records consist simply of the invoices received from the supplier or does he keep an on-the-job record of material delivery or a material delivery record supplemented by a record of the date of use and the specific part of the job on which the material was used? On certain types of projects the cost of equipment may be of great significance, especially in cases where rented equipment is used. What type of equipment use records are

kept for both equipment owned by the contractor and rented equipment?

Another point which is of interest to any contractor is how he is progressing as regards both time and cost to date on the project. How does he go about determining how much money has been spent to date compared with what should have been spent for the work completed? Does he have a method of projecting ahead to the end of the job to determine if he will be over or under the estimated cost? How does he go about determining how the job is progressing as far as time is concerned? Does he use a bar chart or CPM schedule or simply his own evaluation? Assuming the contractor knows there is some difficulty concerning either time or cost, how does he determine where the problem is? Does he have some indictor which tells him where he needs to concentrate his efforts in order to take care of a problem on time or cost overrun?

All of the aforementioned points are subjects of interest in this investigation and with these questions answered a comparison can be made which will show the advantages or disadvantages of the PMS-360 system over the contractor methods and what changes would be necessary to modify the contractor's system to the use of the PMS-360 system.

B. Methods-Contractor A

Contractor A is a General Contractor doing varied types of construction. His volume of business for the preceeding year was $596,000. The following is a discussion of his personal time and cost accounting methods.

1. Estimate

Contractor A's methods of estimating could be considered to

be typical of the industry. His method of estimating material cost is standard in that he does a detailed material takeoff from the plans provided by the owner. The seperate material items are then multiplied by their unit price. The total of all items of material gives the total material cost for the project.

His estimate of labor costs is based on two sources. For items of work with which the contractor is familiar and which have been done by his company before, he can base his estimate on the labor cost on prior jobs or on his own personal experience with similar items of work. For items the contractor is not familiar with he uses a published reference which gives him values to use for construction items of work. The reference used by this contractor is the Construction Pricing and Scheduling Manual by Dodge.

The contractor stated that the accuracy of his time estimate is controlled by the class of worker which actually performs the job, and that there is an extreme amount of variability in the rate of productivity of workers within the same trade.

The contractor estimates equipment costs from his experience alone. The cost of equipment use is expressed as hours of use times an hourly rate. The rates used are based on the standard rental rates in his area at the time.

Overhead costs are expressed as a percentage of the total estimated cost of the job. This percentage is based on experience with overhead cost on previous jobs.

The total estimate is recorded on an estimate sheet of the type shown in Figure 34.

ESTIMATE SHEET

PAGE NO OF PAGES

JOB NAME	CONTRACTOR	ESTIMATE NO
LOCATION	ARCHITECT	DATE
ESTIMATOR	CHECKED BY	BID DATE
JOB DESCRIPTION		

DESCRIPTION	QUANTITY	$	MATERIAL	LABOR	SUBCONTRACT	TOTAL

2. Scheduling

Contractor A uses the bar graph method of scheduling his projects. The bar graph used is broken down into general activities of the job with little detail shown. The time estimates used for the bar graph are based only on the experience of the contractor and do not correlate with the manhour estimates that were prepared in estimating the labor cost of the job.

The contractor stated that he does go through a mental construction of the job in order to plan the bar chart according to the sequence of operations and methods to be used. However, none of this planning is recorded and if he is not watching the job very closely, some of the activities may be done out of the sequence which he had planned or old methods may be used. As the job progresses he attempts to observe situations where new methods may apply due to conditions on the job.

3. Resource Allocation

Contractor A does not schedule manpower needs through the project; men are hired and assigned to the job as needed. He stated that due to the variability of weather and working conditions, he feels it would be an extremely difficult job to schedule manpower needs. He often has some problems with the unions due to his variability in manpower usage and another problem which plagues him is receiving poor quality labor because he has to accept anyon available at the time of need.

On the matter of material resources the contractor orders all material for any job as soon as the job is awarded to him. He gives tenative delivery dates to all suppliers based on his

bar chart. As the job progresses more exact delivery dates are provided.

Equipment is assigned to the jobs as needed without prior scheduling and in some cases difficulty results when the same equipment is needed on more than one job or part of a job.

4. Accounting

The cost accounting system used by Contractor A is a McBee System which was set up for his operation. A flow chart showing the flow of information concerning cost in the contractor's organization is shown in Figure 35.

The material costs are recorded in the following manner. The invoices from the supplier are the original record of material cost. One copy of the invoice is left with the job superintendent when delivery is made. Another copy is sent to the contractors office by the supplier. No record is made on the job of material delivery or date of use. When the invoices are received from the supplier they are recorded in the Accounts Payable Ledger until the date of payment. At the time of payment a voucher of the type shown in Figure 36 is completed with the accompanying record to make payment. At this time the information from the invoice and voucher is recorded in the Voucher or Invoice Register which is shown in Figure 37. The information from this register is then transferred to the Job Cost Ledger monthly. The Job Cost Ledger is shown in Figure 38.

Labor costs have a recording system which originates in the field as would be expected. Each worker is given a Weekly Time and Distribution Report of the type shown in Figure 39. On this

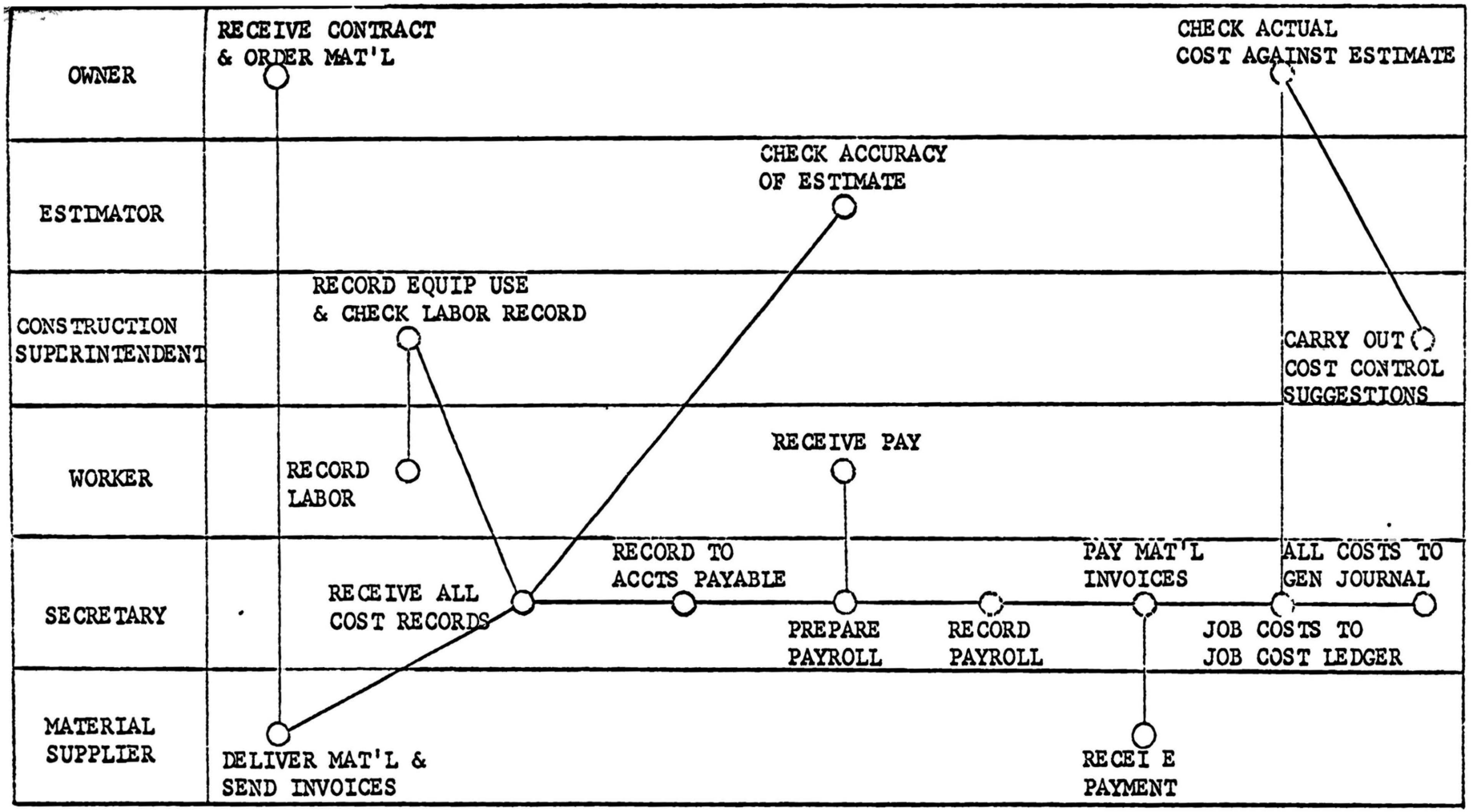


FIGURE 35. CONTRACTOR A - COST INFORMATION FLOW CHART

80-1840
815

FIRST STATE BANK
ROLLA, MISSOURI

DATE

No

PAY
TO THE ORDER OF

⑈0815⑈1840⑈ 476⑈172⑈8⑈

REMITTANCE STATEMENT

BALANCE FORWARD	REFERENCE OR DESC.	DATE	INVOICE AMOUNT	DEDUCTIONS	DISCOUNT OR RATE	BALANCE		REGISTER NO.	
	REMITTANCE SUMMARY								
AP-50	PRINTED IN U.S.A.		INVOICES	DEDUCTIONS	DISCOUNT	CHECK AMOUNT			

MCBEE, ATHENS, O. J96173-6R

FIGURE 36. CONTRACTOR A - PAYMENT VOUCHER

VOUCHER OR INVOICE REGISTER

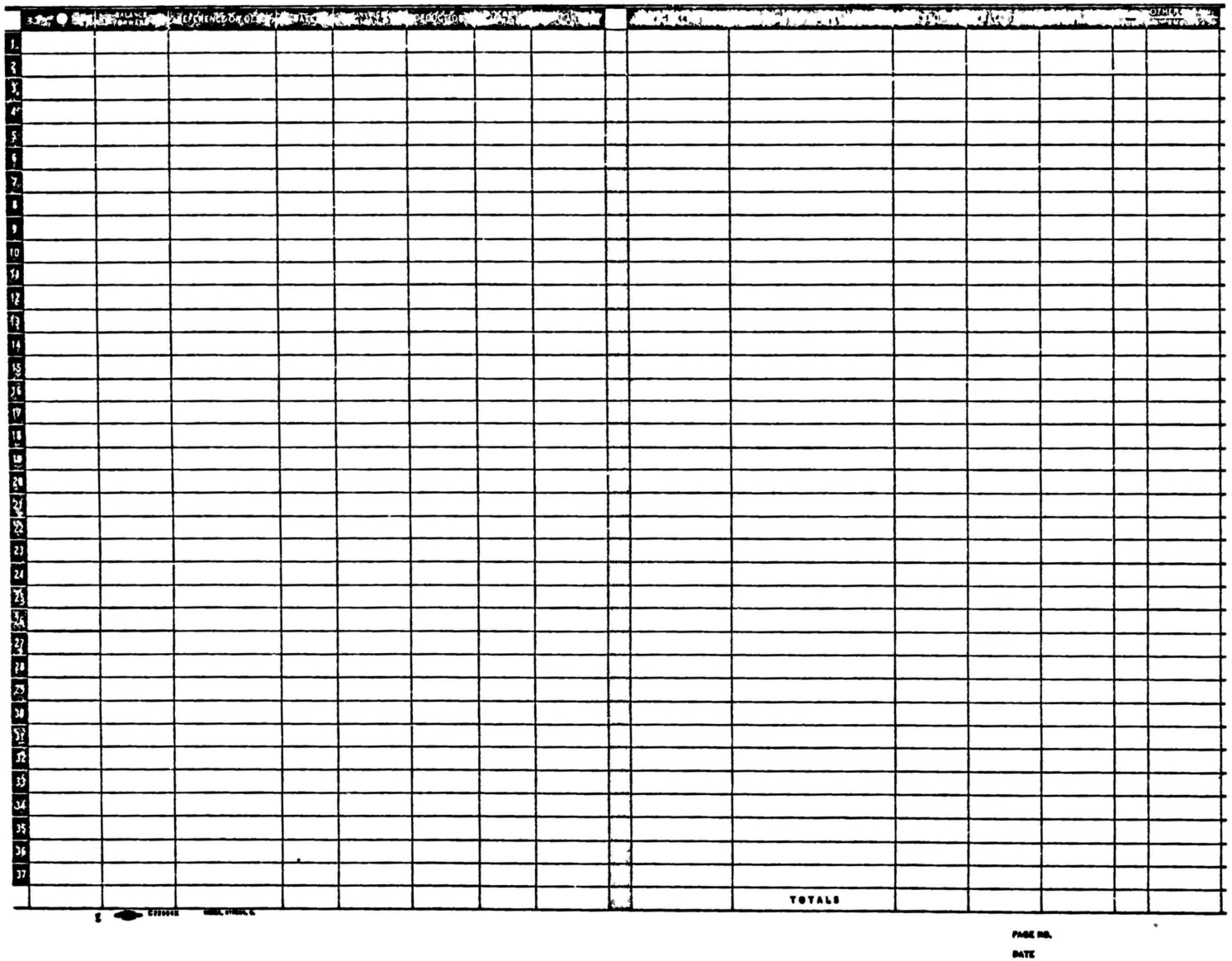
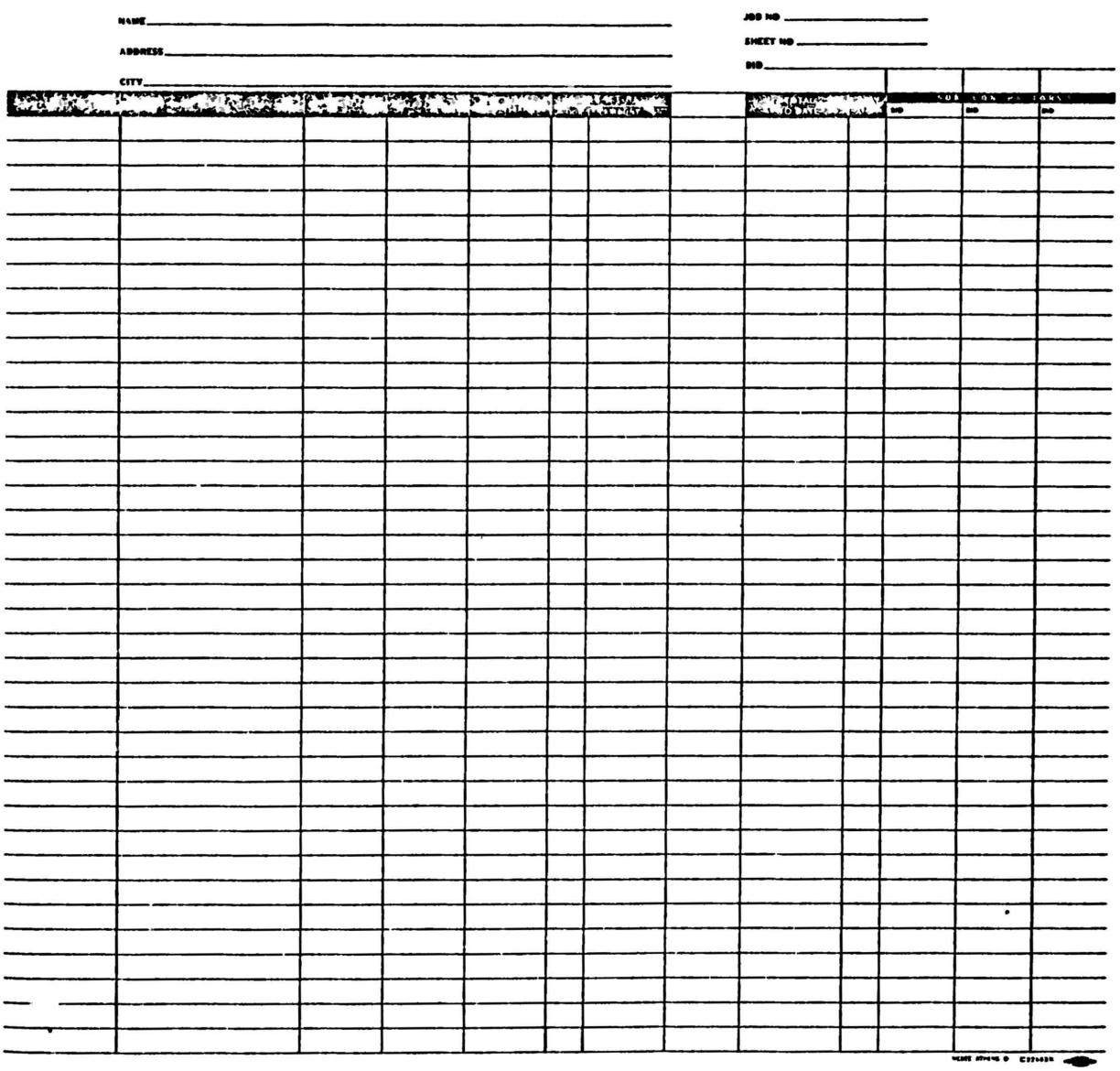


FIGURE 37. CONTRACTOR A - VOUCHER OR INVOICE REGISTER



JOB COST LEDGER

FIGURE 38. CONTRACTOR A - JOB COST LEDGER

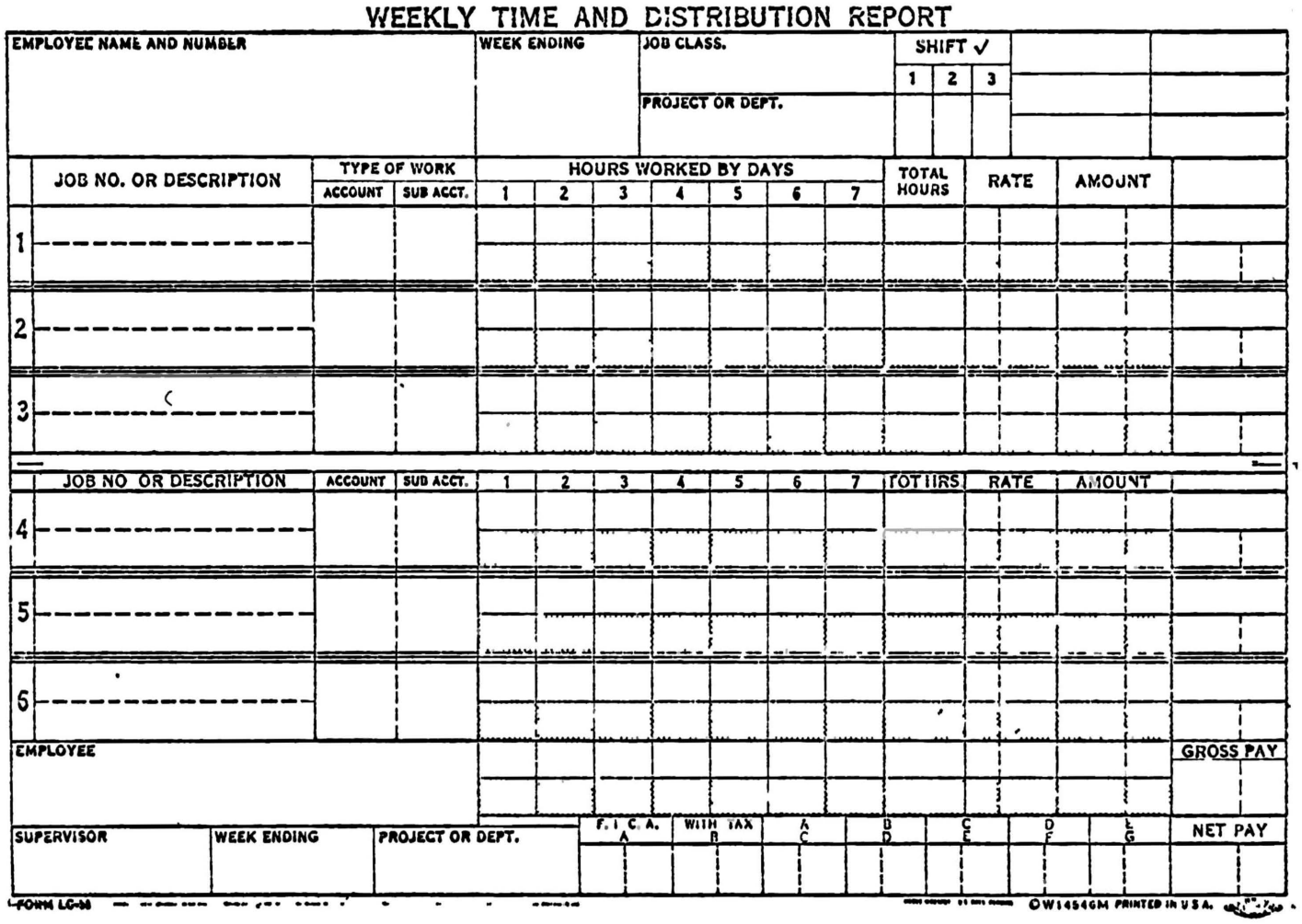


FIGURE 39. CONTRACTOR A - WEEKLY TIME & DISTRIBUTION REPORT

form each worker can record the number of hours worked daily on up to six seperate job or activity. The worker is responsible for recording his time and the job and type of work which he worked on. The type of work is recorded according to the construction chart of accounts shown on pages 84 and 85. The report is presented to the superintendent daily for his OK. At the end of the week or pay period the report is turned in to the office where the payroll calculations are made on the same form. The information from the Weekly Time and Distribution Report is then recorded in two places. It is first recorded in an Individual Earnings Record of the type shown in Figure 40. This record is kept for tax purposes. The information for all employees is then recorded in a Payroll Journal of the type shown in Figure 41. This provides an over-all record of labor costs. The monthly total of labor cost from the Payroll Journal is broken down by job and recorded in the Job Cost Ledger.

The record of equipment use, both contractor owned and rental, is shown in a section of the Daily Progress Report which is shown in Figure 42. This report is kept by the Job superintendent and sent to the office where equipment costs are totaled and recorded to the Job cost Ledger. The Daily Progress Report is also used to record any change orders which are requested and approved for the job. The standard form used for approving change orders and thus making them a part of the contract is shown in Figure 43.

No periodic record of overhead cost is kept. As previously stated, the overhead is figured as a certain percentage of the total job cost and it is not applied until the end of the job.

CONSTRUCTION CODE OF ACCOUNTS

A. Job Layout

B. Excavation

   1. Backfill

   2. Grading

   3. Handgrading

C. Concrete

   1. Pouring

   2. Finishing

   3. Form setting

   4. Form removal and cleaning

D. Steel

   1. Structural

   2. Bar joists

   3. Decking

   4. Reinforcing rods

E. Masonary

   1. Block

   2. Brick

   3. Glazed tile

F. Millwork

G. Windows

   1. Wood

   2. Aluminum

H. Rough Carpentry

I. Plumbing

J. Electrical

K. Insulation

L. Caulking

M. Tile

1. Ceiling

2. Resilient

3. Ceramic

N. Finish Hardware

O. General Cleanup

P. Supervisor

Q. Wrecking

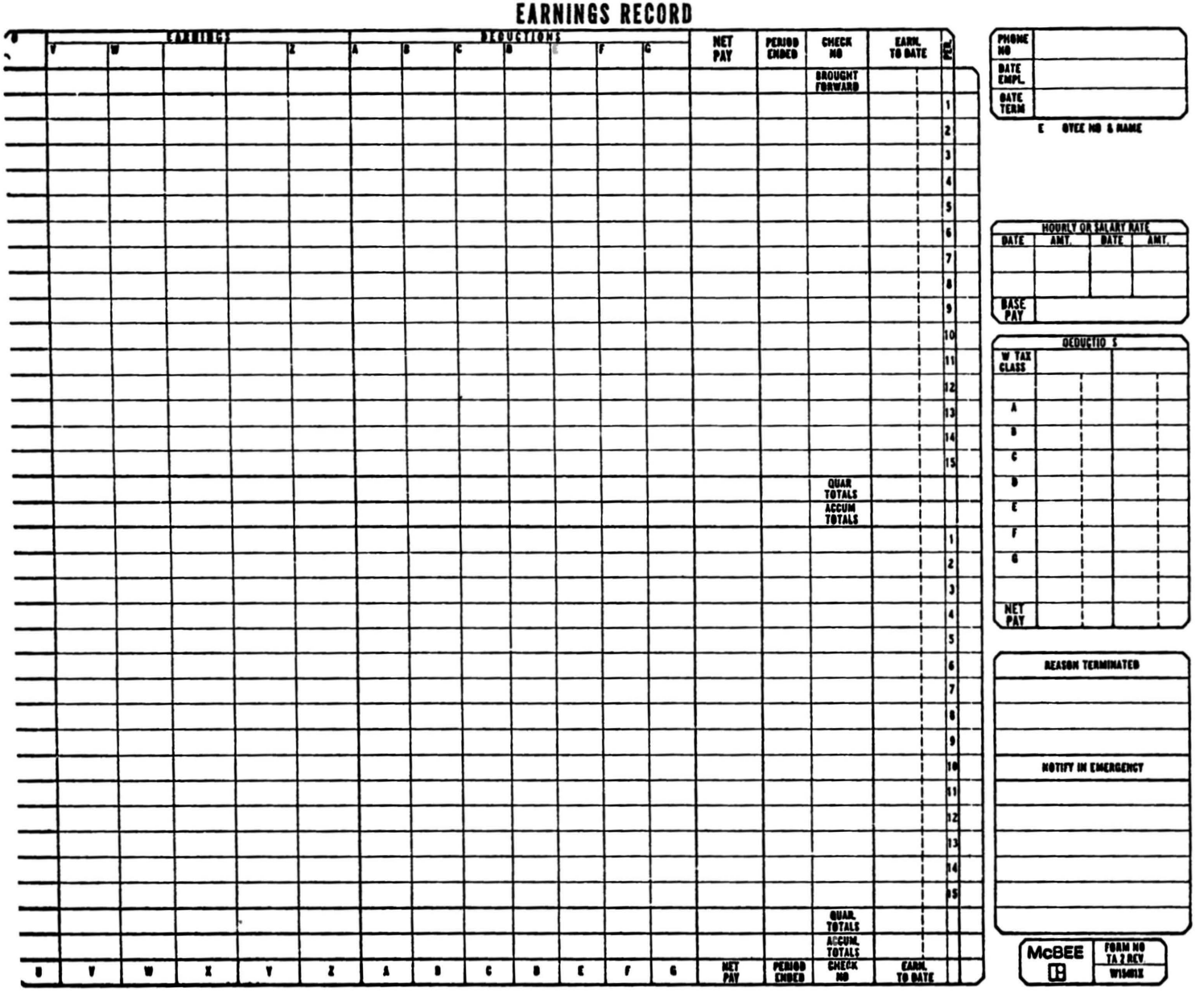


FIGURE 40. CONTRACTOR A - INDIVIDUAL EARNINGS RECORD

PAYROLL JOURNAL

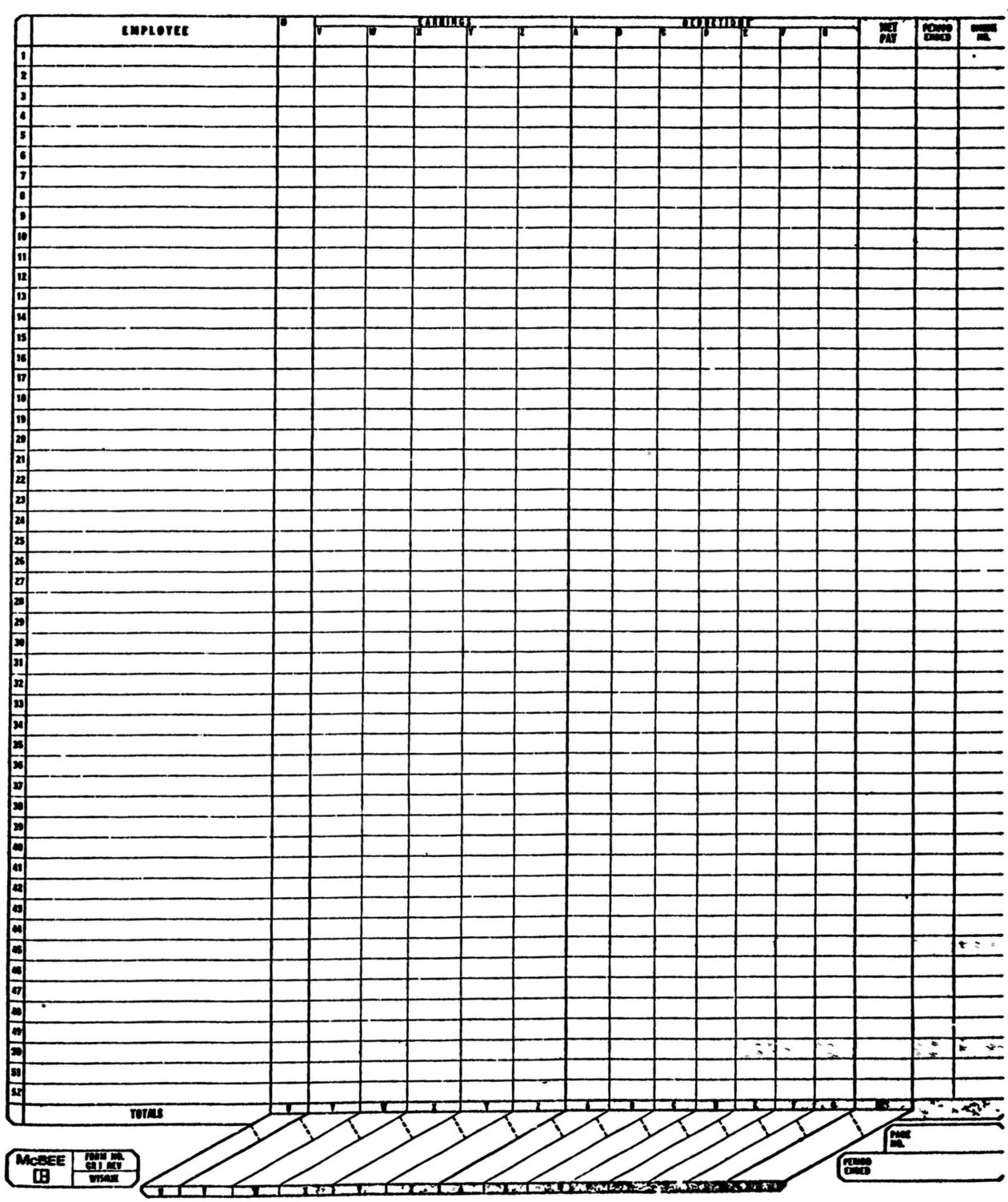


FIGURE 41. CONTRACTOR A - PAYROLL JOURNAL

DAILY PROGRESS REPORT

JOB No _____ Sheet No. _____

FOREMAN'S SIGNATURE _____ DATE _____

JOB NAME _____ AND LOCATION _____

WEATHER CONDITIONS _____ LOW TEMP _____ HIGH TEMP _____

MEN ON JOB	No	TOTAL HOURS WORKED	SUB TRADES ON JOB
Carpenters			
Laborers			
Others			
Brick Masons			
Plumbers			

WORK ACCOMPLISHED AND REMARKS

CHANGE ORDERS OR EXTRAS AS REQUESTED OR APPROVED

EQUIPMENT ON JOB	EQUIPMENT ON RENTAL

FIGURE 42. CONTRACTOR A - DAILY PROGRESS REPORT

CHANGE ORDER

TO	CHANGE ORDER NO
ADDRESS	DATE
	PHONE
JOB NAME AND LOCATION	JOB NUMBER
	DATE OF EXISTING CONTRACT

Note This revision becomes part of, and in conformance with, the existing contract

WE AGREE hereby to make changes as specified above, at this price $

Date _____	PREVIOUS CONTRACT AMOUNT	$
_____ (Authorized Signature)	REVISED CONTRACT TOTAL	$

ACCEPTED: The above prices and specifications of this Change Order are satisfactory and are hereby accepted All work to be performed under same terms and conditions as specified in original contract unless otherwise stipulated

Date _____ Signature _____

FIGURE 43. CONTRACTOR A - CHANGE ORDER FORM

The total of all costs incurred by the contractor, both direct and overhead and for all jobs is recorded in a General Journal according to the Code of Accounts shown on pages 91 to 94. This provides a summary of the overall company costs.

The time accounting procedure involves two forms. These are the Weekly Time and Distribution Report (Figure 39) and the Daily Progress Report (Figure 42). The Weekly Time and Distribution Report provides a record of both the amount of time worked and the type of work performed for each seperate job. The Daily Progress Report provides a record of the number of hours worked by the different trades on the job with only a general description of the work accomplished during that day. A flow chart showing the flow of time information is shown in Figure 44.

5. Progress Reporting

The contractor uses his bar chart in order to predict how he is progressing as far as time is concerned. He stated that in some cases he fails to update the bar chart as work progresses and must then make an estimate of progress by looking at the job and basing his estimate of progress on experience.

The estimate of cost progress is made by use of the Contractor's Monthly Estimate which is shown in Figure 45. This form shows the estimated cost of the job from the estimate sheet, the value completed to the last report; this being taken from the previous month's report; and the value completed since the last report. This last value is taken from the cost data recorded in the Job Cost Ledger. To arrive at a figure for the percentage of completion based on cost, the contractor compares the cost of work completed

OFFICE CODE OF ACCOUNTS

ASSETS

101 Cash

103 Petty Cash

105 Bank-Checking

107 Bank-Savings

109 Bank-Payroll

111 Accounts Receivable-Contract

115 Accounts Receivable-Employees

117 Accounts Receivable-Retainage

121 Notes Receivable

122 Notes Receivable-Officers

131 Inventory

133 Work-in-Progress

151 Equipment (Excluding rental Equipment)

152 Reserve for Depreciation of Equipment

153 Rental Units

154 Reserve for Depreciation_-Rental Units

155 Office Equipment

156 Reserve for Depreciation-Office Equipment

171 Prepaid Insurance

173 Prepaid Interest

175 Union Stamps

177 Plan Deposit

179 Organization Expense

LIABILITIES

201 Vouchers Payable

205 Notes Payable (open)

210 Installment Notes Payable

212 Notes Payable Officers

215 Accrued Sales Tax

221 Accrued Payroll

222 Accrued Withholding Tax - Federal

223 Accrued Withholding Tax - State

224 Accrued Social Security Taxes

225 Accrued Unemployment - Federal

226 Accrued Unemployment - State

227 Accrued Welfare Funds - Union

231 Accrued Federal Income Tax

232 Accrued State Income Tax

NET WORTH

271 Capital Stock Authorization

273 Capital Stock Unissued

275 Retained Earnings

277 Profit and Loss - Current Year

REVENUE

301 Contract Sales

311 Sales - Other

LABOR

401 Direct Labor

403 Welfare Funds and Stamps

CONTRACT ACCOUNTS

404 Material

405 Sub - Contract

DIRECT COSTS (Chargeable to job)

505 Telephone

506 Utilities

507 Equipment Rental

508 Travel Expense

509 Miscellaneous Job Costs

522 Permits

523 Insurance

RENTAL UNITS

631 Gas and Oil - Rental Units

632 Repair and Maintenance - Rental Units

GENERAL EXPENSES

701 Supervision and Estimating Salaries (Not chargeable to job)

703 Welfare Funds (On Supervision and Estimating salaries)

721 Payroll Taxes

722 Taxes and License

723 Insurance (Excluding Performance Bonds)

731 Gas and Oil (Excluding rental units)

732 Repair and maintenance (Excluding rental units)

734 Leases

752 Depreciation (Equipment)

754 Depreciation (Rental Units)

ADMINISTRATIVE

801 Officer Salaries

802 Office Salaries

804 Rent

805 Telephone and Telegraph

806 Utilities

807 Office Supplies

808 Postage

809 Repair & Maintain Office Equipment

811 Travel and Etertainment (Officers)

812 Depreciation Office Equipment

813 Interest

814 Dues and Subscriptions

815 Band Charges

816 Legal and Audit

817 Advertising

818 Miscellaneous

OTHER INCOME

901 Purchase Discounts

905 Miscellaneous Income

910 Gain on Fixed Assets

OTHER DEDUCTIONS

951 Sales Discount

960 Loss on fixed Assets

PROFIT OR LOSS (Current Month)

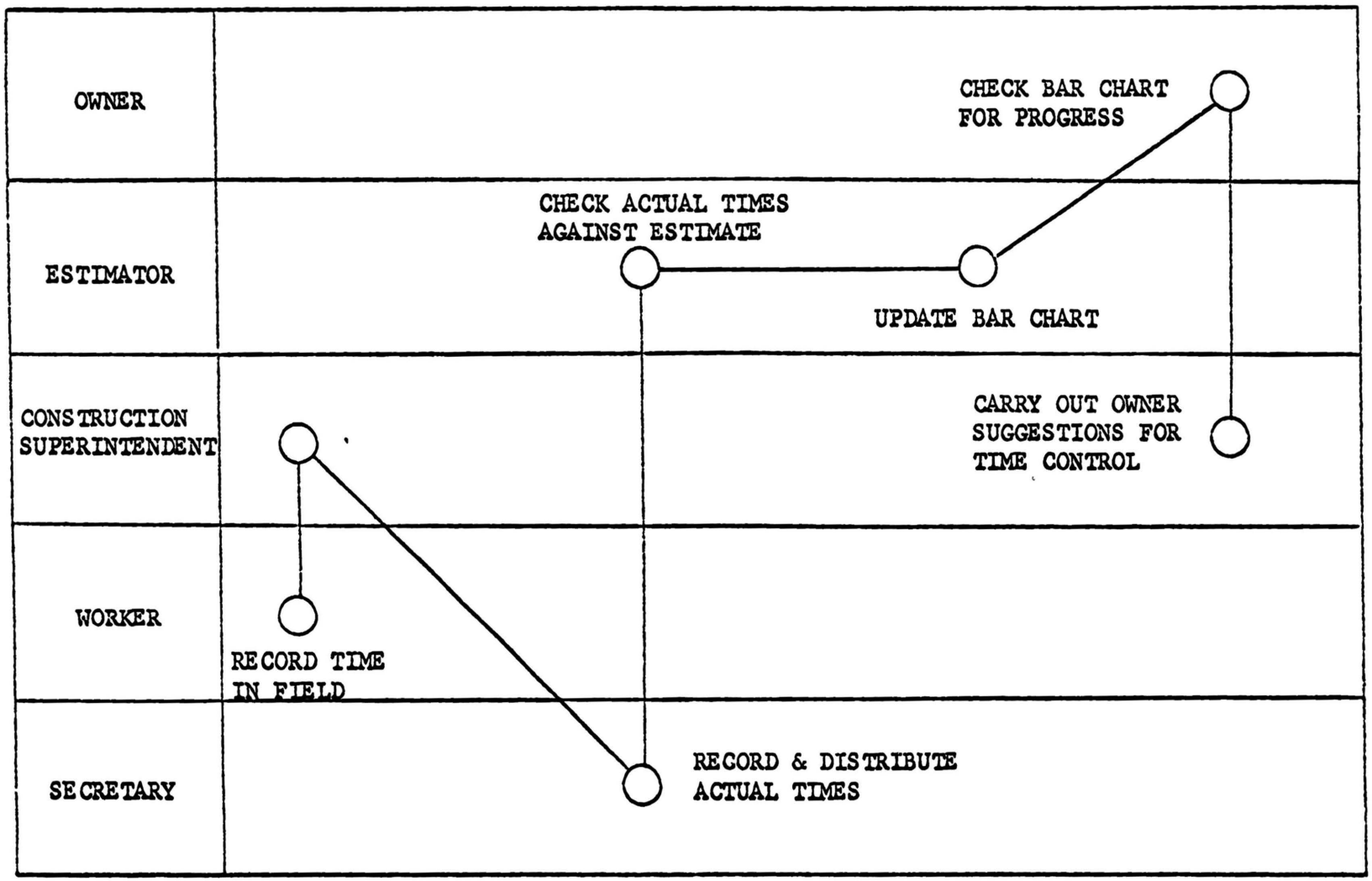


FIGURE 44. CONTRACTOR A - TIME INFORMATION FLOW CHART

CONTRACTOR'S MONTHLY ESTIMATE

Project. _____

Address: _____

Contract Sum: _____

Estimate # _____ Date: _____

Contractor: _____ Address: _____

Project Started: _____ Completion Date: _____

Items of Work	Col. #1 Contract Sum Breakdown	Col #2 Val e Completed to last report	Col. #3 Value Completed since last report
1 Plant Set up and Job layout			
2 Excavation, Filling, Grading			
3 Finish grading, seeding, planting			
4. Concrete Work			
(a) Footings			
(b) Foundations			
(c) Floors			
(d) Reinforced concrete roofs, stairs			
5. Steel			
(a) Reinforcing			
(b) Structural			
(c) Bar joists			
(d) Decking			
6 Masonry			
7. Hollow Metal Doors & Frames			
8 Windows Steel or alum.			
9 Glass and Glazing			
10 Lathing & Plastering			
11 Ceramic & Quarry Tile			
12 Carpentry & Millwork			
(a) Rough carpentry			
(b) Finish carpentry			
(c) Cabinets Built-ins			
13. Finish Hardware			
14 Roofing & Insulation			
15 Insulation blown, batt or blanket			
16 Sheet Metal			
17 Caulking			
18. Waterproofing			
19. Finish flooring			
(a) Resilient floor cov.			
(b) Wood			
(c) Terrazo			
20 Acoustical work			
21 Painting & Decorating			
22 Plumbing			
23 Sewage Disposal System			
24. Heating & Air Conditioning			
25. Electrical			
(a) Wiring			
(b) Fixtures			
26 Special Equipment			
(a)			
(b)			
(c)			
(d)			
(e)			
27.			
28.			
29			
30			
TOTALS			

Total Value of Work completed to Date (Col. #2 plus Col. #3 _____

Extras and/or additions to the Work _____

Sub-Total _____

Less 10% retained: _____

Sub-Total _____

Less Previous Estimates: _____

Amount of this Estimate: _____

FIGURE 45. CONTRACTOR A - MONTHLY ESTIMATE

with the total estimated cost of the job.

C. Methods-Contractor B

Contractor B does varied types of work including a considerable amount of government contracting. His firm is organized into seperate companies which are part of one corporation. The different companies are set up to perform general contracting, sheet metal work, electrical, etc. The following is a description of Contractor B's methods of time and cost control. His volume of business for the preceeding year was approximately $750,000.

1. Estimate

This contractor also follows the somewhat standard method of estimating. The material estimate is composed of a detailed material takeoff from the plans with the number of items being multiplied times the unit cost for each item. A summation of these gives a total material cost.

The time estimates for each part of the job are based primarily on past experience. In the case of jobs t e contractor is not familiar with he either refers to a published reference or someone who does have experience with the job. Standard time estimates are kept from previous jobs and these are used as long as the contractor feels they are valid. When new methods come about for doing jobs the contractor changes his time estimates accordingly.

A detailed equipment estimate, based primarily on the contractor's experience, is prepared just as the material or time estimates are prepared. In most cases this contractor has sufficient equipment of his own to do the jobs. Standard rates

published by the Association of General Contractors are used to calculate equipment use costs. In the case of any rented equipment the rental rate is used as the use rate to be charged to the contract price.

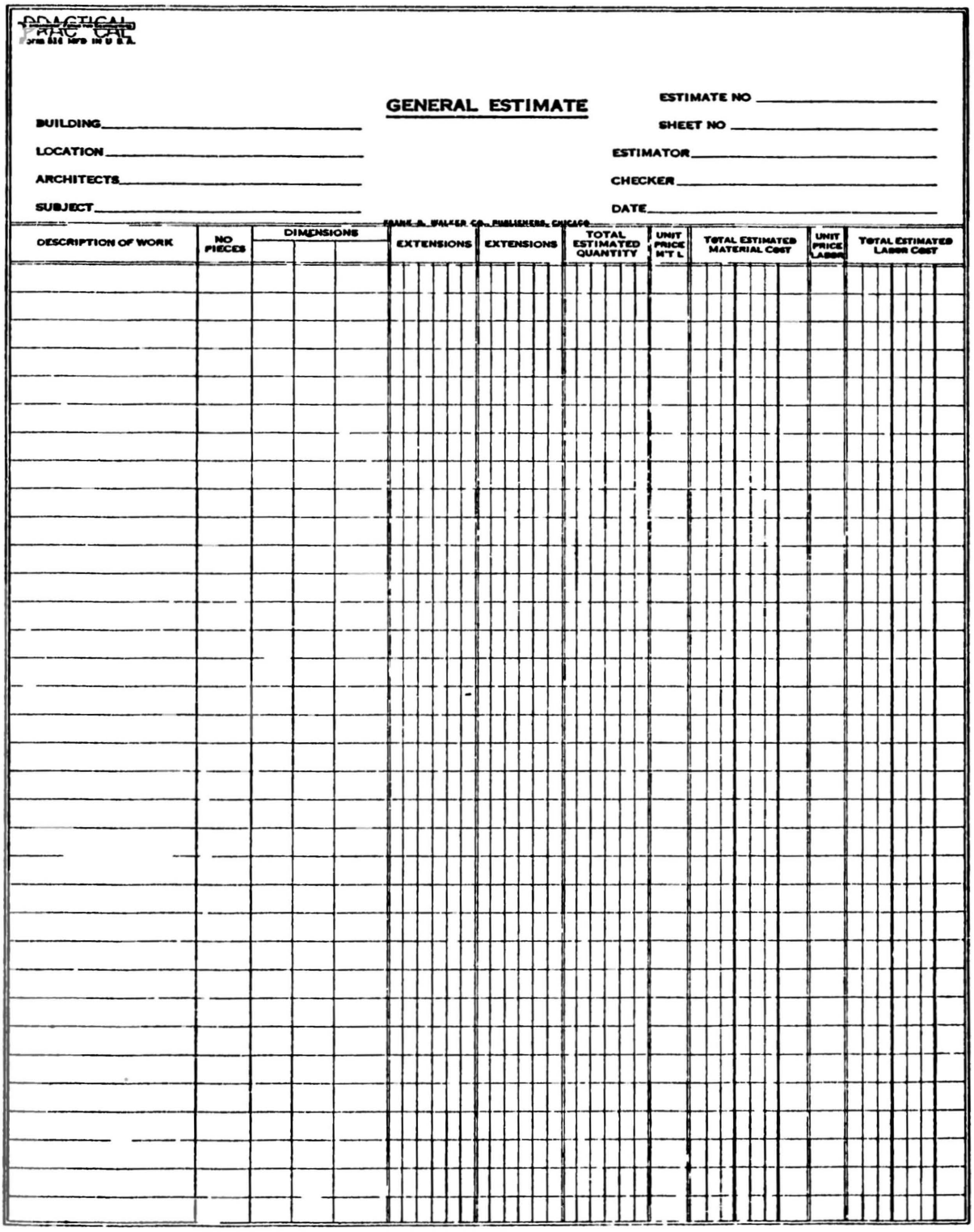
The estimate of overhead cost is based on a certain percent of the total job cost. This is to include standard overhead items, such as three percent of the total labor cost to take into account purchase and repair of hand tools used by the workers. Special overhead items are estimated seperately.

The form used to record the total estimate including material, labor, equipment and overhead is shown in Figure 46.

2. Schedul

Contractor B uses the bar chart for scheduling purposes except on very large jobs. On these he uses the Critical Path Method of scheduling. The time estimates used in preparation of the original cost estimate are used to estimate the durations of the activities on the bar chart of CPM schedule. The bar chart or CPM schedule are checked for progress and updated as often as the contractor feels it is necessary.

Prior to preparing the estimate or schedule for any job, the contractor and his staff of job supervisors meet for a preconstruction planned meeting. At this meeting the alternative construction methods available are discussed and decisions are made as to the best and most economical methods to be used. They also discuss the available manpower including job superintendents, and attempt to choose the best work force for the job. If there are alternatives as to the type or size of equip-



PRACTICAL
PRACTICAL

GENERAL ESTIMATE

BUILDING _____ ESTIMATE NO _____

LOCATION _____ SHEET NO _____

ARCHITECTS _____ ESTIMATOR _____

SUBJECT _____ CHECKER _____

DATE _____

FRANK B. WALKER CO., PUBLISHERS, CHICAGO

DESCRIPTION OF WORK	NO PIECES	DIMENSIONS			EXTENSIONS	EXTENSIONS	TOTAL ESTIMATED QUANTITY	UNIT PRICE MT'L	TOTAL ESTIMATED MATERIAL COST	UNIT PRICE LABOR	TOTAL ESTIMATED LABOR COST

FIGURE 46. CONTRACTOR B - GENERAL ESTIMATE FORM

ment which can be used these decisions are made.

3. Resource Allocation

He does not schedule manpower from the bar chart or CPM schedule as to the number of workers which will be needed during any specific time period in the job. He does make some attempt at leveling manpower even though he may not think of it as that.

He maintains a nucleus of manpower as much as possible. A basic crew is set and can be strengthened or lightened according to the work load or the type of work being done. He attempts to keep this basic crew busy as much as possible because he has chosen them knowing something of their reliability. If he has to lay them off he may not be able to get them back and the replacements may not be nearly so reliable. Concerning manpower, he also stated that at this time there is a shortage of manpower in certain trades and he has trouble acquiring men from these trades when he needs them. This is one of his main reasons for attempting to keep a constant force of reliable men from each trade which he will need on a job.

In order to assure that material will be delivered on time the contractor places an order for all material needed on the job as soon as the bid for the job is ready to be submitted. This order is subject to his getting the job. This allows the suppliers to begin determining any problems in acquiring the material. Tenative delivery dates are given based on the bar chart or CPM network. More definate delivery dates are given as the job progresses.

Contractor B does schedule equipment needs in order to prevent duplicate need of equipment on more than one part of a job or on different jobs. If this problem should arise and the contractor feels it could delay the project he rents the needed piece of equipment.

4. Accounting

The cost accounting system used begins with records from the field and suppliers of material. These records are then assembled and records kept using the Borroughs Bookkeeping machine. A flow chart showing the flow of cost information through his organization is shown in Figure 47.

Records of material costs are kept by two methods. When the material is received on the job the superintendent checks to see that the material delivered agrees with the invoice. He then signs the invoice and keeps one copy. These invoices are recorded in the Material Cost form shown in Figure 48, by the superintendent. He then sends his copy of the invoice to the office. The supplier sends his copy of the invoice to the contractors office as a statement of payment due. The two copies of the invoices are checked against each other for accuracy. The information from the invoices is then recorded on the Accounts Payable Ledger (Figure 49) for later payment. When the accounts are paid the information is recorded to the Job Cost Ledger (Figure 50) which provides a record of cost for each seperate job. When payment occurs the payment is recorded in the General Ledger shown in Figure 51. This form provides an overall record of company expenditures and receipts.

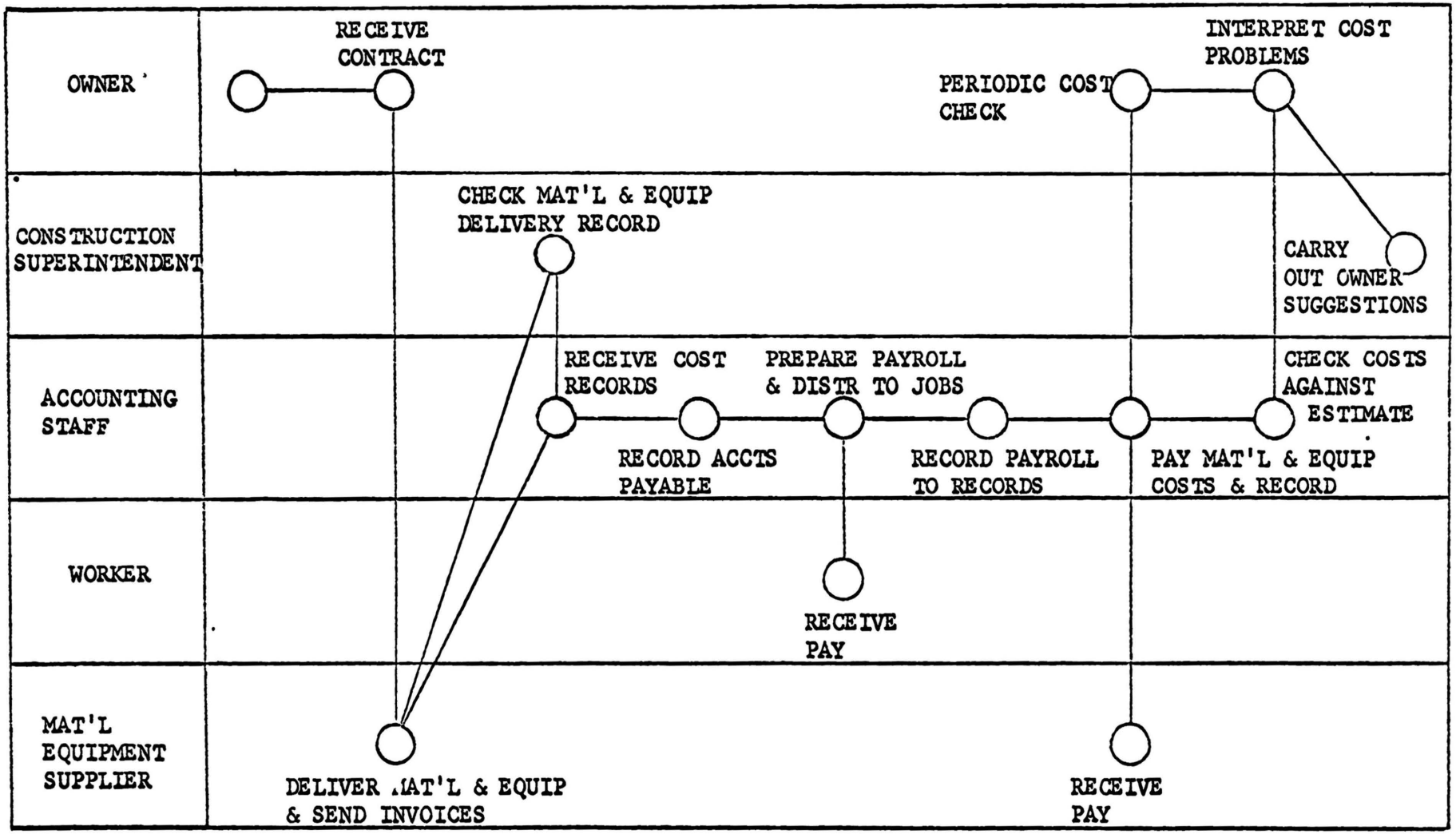


FIGURE 47. CONTRACTOR B - COST INFORMATION FLOW CHART

_____ JOB # _____

_____ MATERIAL COSTS SHEET # _____

DATE	SUPPLIER	INVOICE #	AMOUNT	TOTAL TO DATE

ACCOUNTS PAYABLE

NAME
ADDRESS

DATE	REFERENCE	DEBITS	CRED TS	BALANCE

FIGURE 49. CONTRACTOR B - ACCOUNTS PAYABLE LEDGER

JOB COST LEDGER

JOB NO

NAME

DATE	REFERENCE	JOB NO	LABOR	MATERIAL	MISC	RENTAL EQUIPMENT	BACK CHARGES		CREDITS	BALANCE
							DEBITS	CREDITS		

FIGURE 50. CONTRACTOR B - JOB COST LEDGER

GENERAL LEDGER

NAME
ACCOUNT NO.

DATE	REFERENCE		DEBITS	CREDITS	BALANCE
	CHECK NO	ACCOUNT NO.			

FIGURE 51. CONTRACTOR B - GENERAL LEDGER

Periodically the field record of material cost is compared with the record of the Job Cost Ledger.

The labor cost records originate in the field on the form shown in Figure 52. The formeman records daily each workers time and occupation and distributes the time to the seperate jobs or parts of a job. This form is sent to the accounting office daily. He also records the labor costs on the Labor Cost form shown in Figure 53 for his own records. The information f om the daily labor cost records sent to the office is recorded on the weekly labor record shown in Figure 54 for payroll purposes. The labor cost for each job is then recorded in the Job Cost Ledger (Figure 50). A payroll record for each employee is kept on a form of the type shown in Figure 55 and is used for tax purposes. When payment is made for labor costs the information is recorded in the General Ledger as to whether they are direct, indirect, office, or administrative. The code of accounts used to record information in the General Journal is shown on pages 112 to 114.

Equipment use cost are recorded in the field on the same form as labor cost and reocrded in the Job Cost Ledger when received in the office.

No record is kept of overhead cost but when the contractor wishes to prepare a cost progress report, overhead costs are included as a percentage of the cost to date.

The same forms are used for keeping a record of time on the job as are used for keeping payroll records. The daily labor records give a breakdown of hours spent, classification

DATE _____ 19____

JOB _____

TODAY'S PRODUCTION

DISTRIBUTION

INSTRUCTIONS

FOREMEN WILL WRITE IN CLASSIFICATIONS OF WORK DONE IN THE DISTRIBUTION COLUMNS, NAMES OF MEN OCCUPATIONS, REGULAR TIME AND OVERTIME

TIMEKEEPER WILL INSERT RATES OF PAY AND CARRY OUT ALL EXTENSIONS.

SUBMIT DAILY

NAME	OCCUPATION	INDICATE STRAIGHT TIME ON BOTTOM LINE OVERTIME ON TOP LINE	TOTAL HOURS	RATE	TOTAL PAY

JOB # _____

LABOR COSTS SHEET # _____

DATE	AMOUNT	B/C LABOR	TOTAL TO DATE

FIGURE 53. CONTRACTOR B - LABOR COST FORM

Contractor
Address
Contract No
Type

Pay Roll No Sheet No of
Federal Project No
State County
Week Ending

DAY AND DATE

NAME OF EMPLOYEE	NO DEP	OCCUPATION CLASSIFICATION							TOTAL HRS	WAGE RATE		AMOUNT EARNED	O A B TAX	FED. W. H. TAX	MO. W. H.	AMOUNT PAID	CHECK NUMBER

FIGURE 54. CONTRACTOR B - WEEKLY LABOR RECORD

EARNINGS & DEDUCTIONS RECORD

EMPLOYEE'S NAME

ADDRESS

CITY

SOCIAL SECURITY NO | NUMBER OF DEPENDENTS | CLOCK NO

EARNINGS			DEDUCTIONS							NET
REGULAR	EXTRA	TOTAL	WITH TAX	FOAB					MISC CODE	

YEAR TO DATE			PROOF	PERIOD ENDING	HOURS WORKED	EARNINGS			DEDUCTIONS							NET AMOUNT
EARNINGS	WITH TAX	FOAB				REGULAR	EXTRA	TOTAL	WITH TAX	FOAB					MISC CODE	

FIGURE 55. CONTRACTOR B - EARNINGS & DEDUCTIONS RECORD

OFFICE CODE OF ACCOUNTS

ASSETS

110 Bank Accounts

111 Payroll Accounts

120 Notes Receivable

130 Accounts Receivable

140 Inventories

150 Warehouse - Stock

160 Loans to Employees

210 Investments

220 Equipment and Buildings

221 Reserve for Depreciation

230 Automotive Equipment

231 Reserve for Depreciation

240 Office Furniture and Equipment

241 Reserve for Depreciation

250 Real Estate

270 Prepaid Expenses

280 Utility Deposits

281 Plans Deposits

310 Notes Payable

320 Accounts Payable

330 Due to Officers

340 Accrued Taxes

350 Accrued Salaries

360 Other Accruals

370 Cilinder Deposits

371 Hard Hat Deposits

380 Withheld Taxes

440 Capital Stock

450 Surplus

460 Profits and Overhead

470 Retentions

510 Income : Discount

530 Income : Materials

540 Income : Miscellaneous

LIABILITIES

600 Job Cost (Credit Only)

610 Labor : Direct

611 Labor : Other

612 Union Benefits Fund

613 Travel Pay

620 Materials

621 Freight

630 Miscellaneous

640 Equipment Rental

650 Subcontracts

720 Labor, General Expense

721 Office Supplies

731 Motor Fuel

732 Tires and Tubes

740 Equipment Repairs

750 Utilities

760 Insurance

770 Taxes and Licenses

780 Miscellaneous Expenses

781 Advertising

782 Bidding Jobs

783 Donations

784 Dues and Subscriptions

785 Freight, Miscellaneous

786 Interest

787 Legal and Audit Fees

810 Salaries, Superintendents

820 Salaries, Officers

of worker and the job or activity worked on. The labor is recorded according to the Association of General Contractors Code of Accounts. A flow chart showing the flow of time information in the contractor's organization is shown in Figure 56.

Contractor B has been using this accounting system for a number of years, he is satisfied with the system and stated that he is not interested in any change.

5. Progress Reporting

Contractor B uses the bar chart or CPM schedule which is prepared for each job in order to evaluate time progress. He uses the time information from the daily reports along with observance of the job itself in order to update the bar chart or schedule. He stated that the bar chart or schedule 's always updated so that he has something to base his time progress on.

The cost progress reporting is done by comparing the information in the job cost ledger with the original cost estimate. A percentage of the cost to date is included for overhead. The accounting staff is provided with a copy of the estimate and make peridoic comparisons of actual costs against estimated costs and report any significant points to the owner. He then takes appropriate action. The owner also makes periodic checks of overall costs.

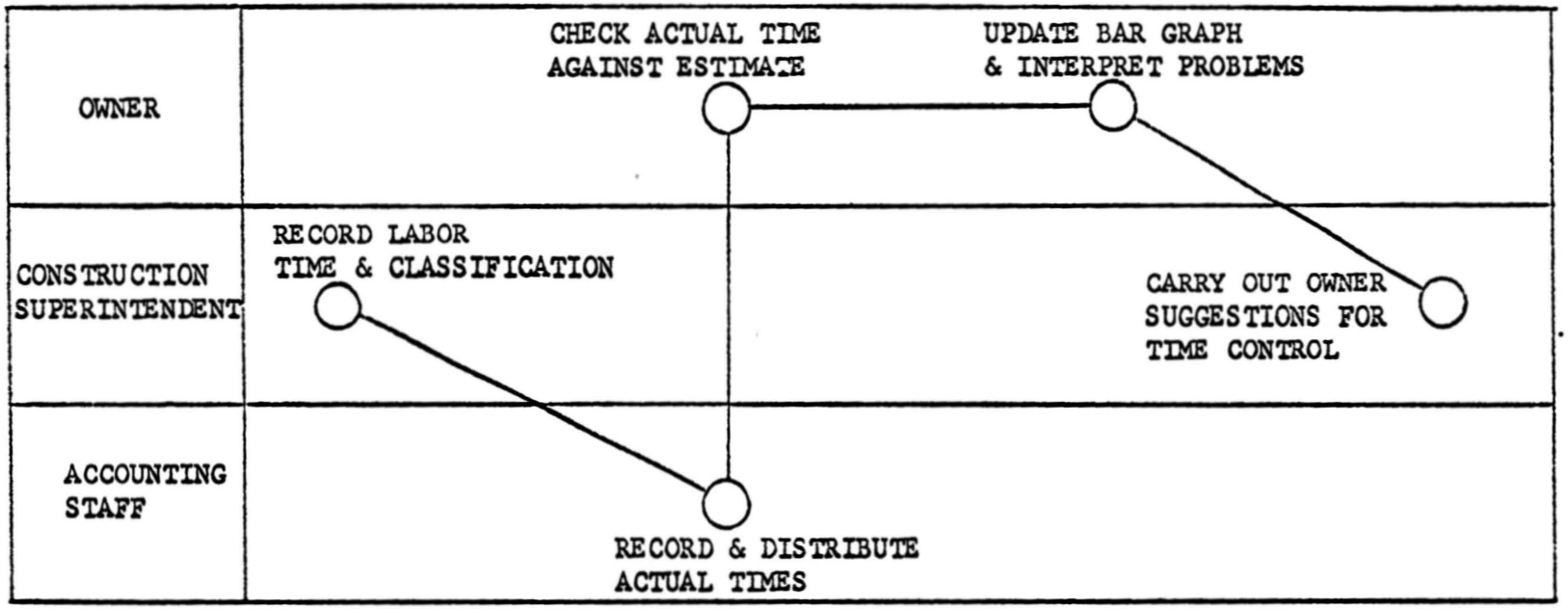


FIGURE 56. CONTRACTOR B - TIME INFORMATION FLOW CHART

D. Methods-Contractor C

Contractor C is a relatively large general contractor. His volume of business for the preceeding year was approximately $5,000,000. The following is a description of the time and cost control methods which he uses.

1. Estimate

Contractor C also uses the standard method of estimating material cost. He makes a detailed material takeoff from the plans and extends the quantities times a unit price to come up with the total material cost.

The estimate of labor cost comes almost from his file of historical data. When each job is finished, the daily time tickets which show the time worked and classification of work are analyzed in detail in order to determine the time necessary to complete each part of the job shown in the Construction Chart of Accounts. This Chart of Accounts is shown on the following pages. This information is then used in preparing later estimates along with other factors such as location of job, job conditions, storage, availability of labor, etc.

The contractor also estimates equipment cost according to historical data. He owns sufficient equipment to do all work in most cases. The rates which are used for equipment costs are based on rates published by the American Equipment Distributors. Except for small jobs, equipment is charged to the job by the month. For small jobs it may be charged to the job by the day or week.

Overhead costs are expressed as a percentage of the total labor cost of the job, however, detailed estimates of the seperate

overhead costs are made in order to verify the percentage to be used.

The detailed estimate is recorded and calculated on the General Estimate form shown in Figure 57. This form is then summerized and a more brief estimate recorded and submitted on the Summary of Estimate form shown in Figure 58.

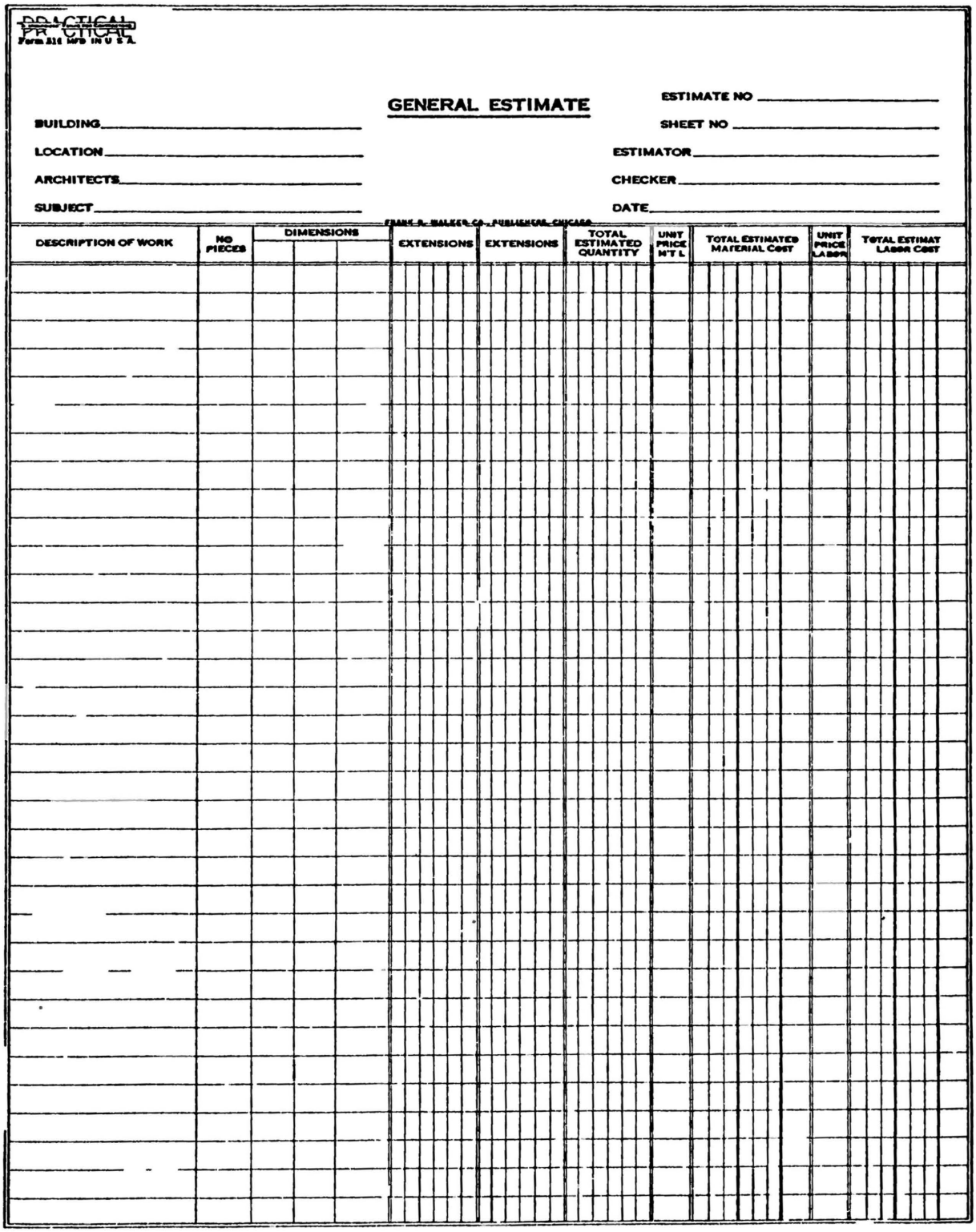
2. Schedule

Contractor C used the bar chart for scheduling of projects. He uses the time estimates from the original estimate in order to determine the duration of the seperate activities on the bar chart. In order to determine the divisions of the bar chart he goes through a process of preplanning the job and even goes to the extend of making details of construction methods to supplement the plans. The methods set out in these details are used in construction unless the field superintendent feels that a different method would be more economical or do the job better.

3. Resource Allocation

Contractor C does not schedule manpower but does have some degree of leveling as stated below. He uses a basic nucleus o manpower and draws from unions when extra men are needed. He stated that prior to construction he attempts to check on how much construction will be in progress in the area and how it will affect the labor market. This enables him to plan ahead to some extent concerning how large a nucleus of manpower he should employ.

In order to assure delivery of material on time the material for the project is ordered after he has received the contract for the job unless there are special items that may be difficult



PRACTICAL
Form 814 MFD IN U S A.

GENERAL ESTIMATE

ESTIMATE NO _____
SHEET NO _____
BUILDING _____
LOCATION _____
ESTIMATOR _____
ARCHITECTS _____
CHECKER _____
SUBJECT _____
DATE _____

FRANK B. WALKER CO., PUBLISHERS, CHICAGO

DESCRIPTION OF WORK	NO PIECES	DIMENSIONS			EXTENSIONS	EXTENSIONS	TOTAL ESTIMATED QUANTITY	UNIT PRICE M'T'L	TOTAL ESTIMATED MATERIAL COST	UNIT PRICE LABOR	TOTAL ESTIMAT LABOR COST

FIGURE 57. CONTRACTOR C - GENERAL ESTIMATE

PRACTICAL

FORM 116

SUMMARY OF ESTIMATE

BUILDING | LOCATION | ESTIMATE NO

ARCHITECT | OWNER | DATE

CUBICAL CONTENTS | NO OF STORIES | COST PER CUBIC FOOT | ESTIMATOR

FLOOR AREA SQUARE FEET | COST PER SQUARE FOOT | CHECKER

CLASSIFICATION	TOTAL ESTIMATED MATERIAL COST	TOTAL ESTIMATED LABOR COST	TOTAL SUB BIDS	TOTAL	ADJUSTMENTS
1 GENERAL CONDITIONS AND OVERHEAD EXPENSE					
2 PERMITS, INSURANCE, BONDS AND TAXES					
3 CONSTRUCTION PLANT, TOOLS AN EQUIPMENT					
4 WRECKING AND CLEARING SITE					
5 EXCAVATING AND PUMPING					
6 SHORING AND UNDERPINNING					
7 PILING OR CAISSONS					
8 FOUNDATIONS AND RETAINING WALLS					
9 WATER AND DAMPPROOFING					
10 CEMENT FLOORS, WALKS AND PAVEMENTS					
11 BRICK, TILE AND CONCRETE MASONRY					
12 CAST STONE, CUT STONE OR GRANITE					
13 TERRA COTTA					
14 ARCHITECTURAL CONCRETE					
15 REINFORCED CONCRETE					
16 TILE, GYPSUM OR CONCRETE BLOCK FIRE PROOFING					
17 ROUGH CARPENTRY					
18 FINISH CARPENTRY					
19 WOOD FLOORS					
20 INSULATION, SOUND DEADENING, ACOUSTICAL TILE					
21 WEATHER STRIPS AND CAULKING					
22 LATHING AND PLAST RING					
23 FIRE DOORS AND WINDOWS					
24 HOLLOW METAL DOORS AND TRIM					
25 STEEL SASH DOORS, PARTITIONS, SKYLIGHTS					
26 SHEET METAL WORK, SKYLIGHTS, FLASHINGS, ETC.					
27 ROOFING, BUILT-UP, TILE, SLATE, METAL					
28 TILE AND MOSAIC FLOORS, WALLS, STAIRS					
29 ASPHALT, CORK, LINOLEUM AND RUBBER TILE					
30 ART MARBLE AND SCAGLIOLA					
31 MARBLE AND SLATE					
32 GLASS AND GLAZING, STRUCTURAL GLASS					
33 PAINTING AND DECORATING					
34 STRUCTURAL IRON AND STEEL					
35 MISCELLANEOUS IRON AND STEEL					
36 ORNAMENTAL IRON, ALUMINUM, BRONZE, STEEL					
37 ROUGH HARDWARE					
38 FINISH HARDWARE					
39 PLUMBING, SEWERAGE AND GAS-FITTING					
40 VACUUM CLEANING S STEM					
41 HEATING AND VENTILATING					
42 AIR CONDITIONING					
43 POWER PLANT EQUIPMENT					
44 ELECTRIC AND POWER WIRING					
45 LIGHTING FIXTURES					
46 ELEVATORS, ESCALATORS, DUMB WAITERS					
47 AUTOMATIC SPRINKLER SYSTEM					
48 MAIL CHUTE					
49.					
50.					
51.					
52.					
53.					
54.					
55. TOTALS					
56.	TOTAL COST				
57.	PROFIT				
58.	SURETY BOND				
59.	AMOUNT OF BID				

FIGURE 58. CONTRACTOR C - SUMMARY OF ESTIMATE

to acquire. In this case he may order the material prior to receiving the contract subject to his receiving the contract. Tentative delivery dates are given based on the bar chart and these may be changed as the job progresses.

Contractor C doe not schedule equipment needs. If the same piece of equipment is needed on more than one job and the contractor feels that it is critical to use the equipment now, he rents the necessary equipment. The criticality of need is based on experience alone.

4. Accounting

The basic accounting system of the company was established some time ago and changes have been made as deemed necessary by the management based on company growth and change in the industry. A flow chart showing the flow of cost information in the contractor's organization is shown in Figure 59.

The record of labor cost originates with the job superintendents recording daily each workers time the field for each job. This record is made on the form shown in Figure 60. A code is also recorded with the time in order to describe the type of work done. The breakdown of this code is shown on pages 124 to 131. These time cards are sent to the office weekly for preparation of the payroll. The payroll information is recorded to the payroll journal to provide an overall payroll records. The payroll journal is shown in Figure 61. The record of each individuals payroll is recorded to the individual payroll record form shown in Figure 62 for tax records. The total of the payroll for all projects is recorded in a General Journal.

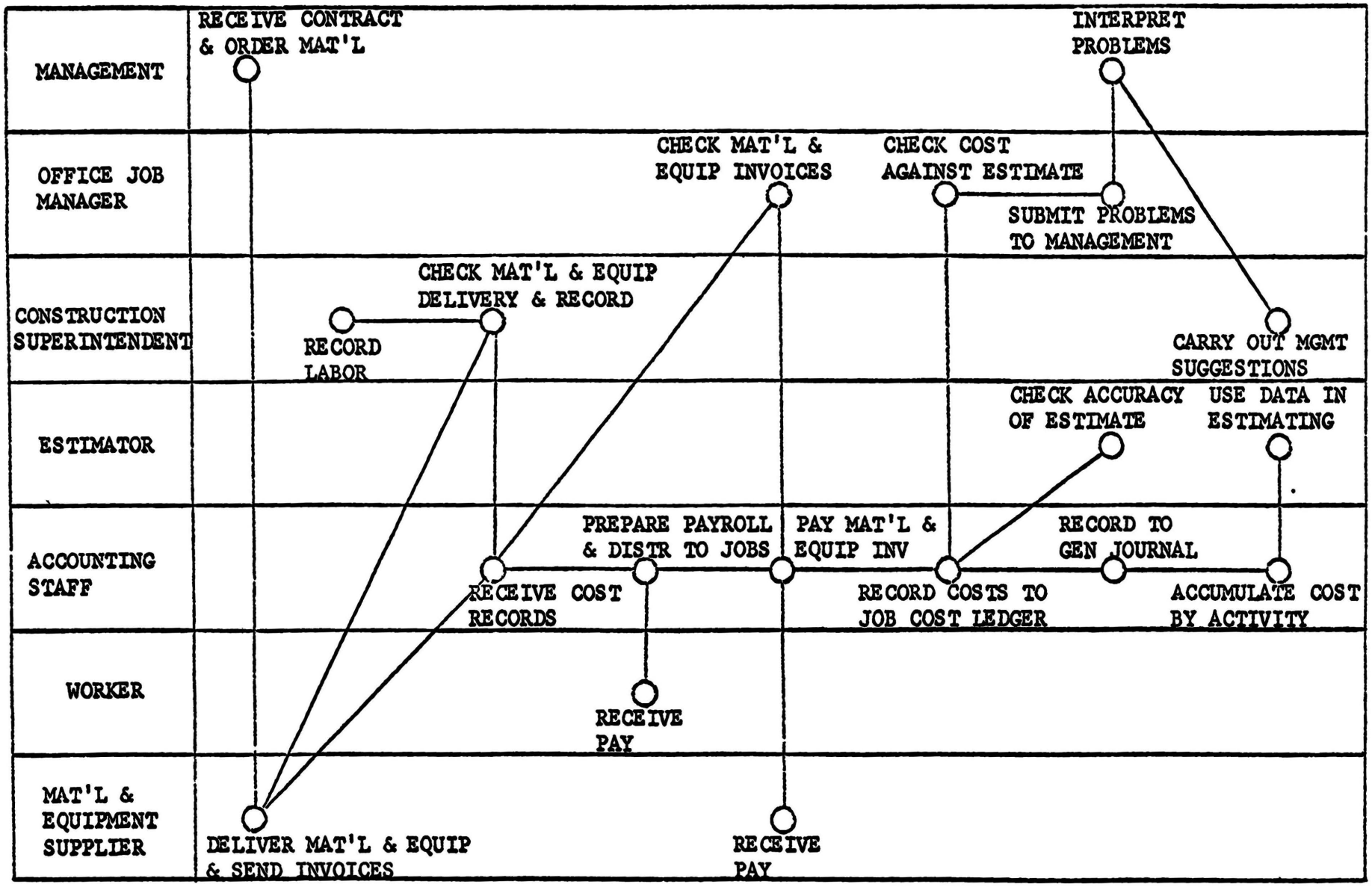


FIGURE 59. CONTRACTOR C - COST INFORMATION FLOW CHART

Name _____ Occup. _____

Back Charge _____

Day	Code	Reg.	Spec.	1½	2		Total Hrs. Reg	Spec.	1½	2
Thurs.										
Fri.										
Sat. or Sun.										
Mon.										
Tues.										
Wed.										

Reg. time_____Hrs. @_____ $_____

Spec. time_____Hrs. @_____ $_____

1½ time_____Hrs. @_____ $_____

2 time_____Hrs. @_____ $_____

Other_____Hrs. @_____ $_____

Total Hrs._____Total Earnings_____

FIGURE 60. CONTRACTOR C - DAILY TIME RECORD

CONSTRUCTION CODE OF ACCOUNTS

PRELIMINARY WORK "P"

P Remove trees

P1 Protect trees

P2 Remove top soil

P3 Cut

P4 Fill

P5 Remove building framing

P6 Remove building foundation

P7 Wrecking in existing building

P8 Cut openings in concrete walls

P9 Cut opening in brick walls

P10 Remove sidewalk and driveways

P11 Remove reinforced concrete

EXCAVATION "E"

E General excavation

E1 Trench excavation

E2 Pit excavation

E3 Interior backfill

E4 Exterior backfill

E5 Excavate footings

E6 Grade earth floors

E7 Grade floors (rock)

E8 Rock excav.- general

E9 Rock excav.- footings

E10 Finish Grade (exterior bldg.)

E11 Drilled piers, (pump water, clean out, pour, casings, etc.)

E12 Drilled piers rock excav.

E13 Drain tile (grade, lay, gravel, and backfill)

E14 Pump water

E15 Set culvert (excav. backfill and set)

REINFORCING CONCRETE "R"

R Pour concrete (pour footings, walls, columns, elevated beams, grade beams, elevated slabs, mech. bases)

R1 Pour screed and finish large slab on grade (areas larger than 150 sq. ft.)

R2 Pour screed and finish small slab on grade (areas less than 150 sq. ft.)

R3 Finish flat slab (elevated or formed)

R4 Finish bases (machine bases, range bases, locker bases, etc.)

R5 Stairs on grade (form, pour, finish)

R6 Elevated stairs (forms, pour, finish)

R7 Rough finish slab on grade (elevated or formed)

R8 Pour and rough finish slab on grade

R9 Topping (screed, pour, finish and clean) for slab.

R10 Topping Stairs (pour, finish and clean)

R11 Rub walls, columns, basement (including scaffolding, mixing mortar)

R12 Rub ceilings

R13 Waterproof walls

R14 Sidewalk (grade, form, pour and finish, exp. joints)

R15 Saw joints

R16 Curbs - straight (grade, form, pour, exc. and finish)

R17 Curbs - curved (grade, form, pour, exc. and finish)

R18 Grout columns

R19 Expansion joints

R20 Floor hardener

R21 Pan filled risers (pour and finish

R22 Pan filled platforms (pour and finish)

CARPENTRY "F" (F thru F24 rough carpentry, related to concr.)

F Walls forms, (plates, bulkheads, keyway, wreck and clean, oil forms, pilasters, watch pour)

F1 Short wall forms, (short in height or length or both such as pits, sumps, porches, etc.)

F2 Circular shaped wall forms, (pits, sumps, porches, etc.)

F3 Grade beam forms

F4 Column forms, (make, clamps, place, wreck, etc.)

F5 Beam forms, (make, clamps, place, wreck, etc.)

F6 Deck forms, (make, clamps, place, wreck, etc.)

F7 Centering (pan slabs, T-shores, mud sills, braces, wreck)

F8 Edge forms @ slab

F9 Curb forms @ roofs, sumps, etc.

F10 Form stair on grade (see conc. R5)

F11 Form elevated stairs, (see conc. R6)

F12 Brick ledges (make, place, wreck)

F13 Haunches

F14 Floor depressions

F15 Chamfer strips

F16 Beam pockets

F17 Rough bucks (poured in canc., doors or othe openings)

F18 Anchor bolts

F19 Bolted plates to concr.

F20 Waterstop

CARPENTRY "C"

C Wood doors, (wood bucks, doors, trim, head, stops, back plates, closures)

C1 Hollow metal frames

C2 Hollow metal doors (doors, hardware, closure, etc.)

C3 Wood door in hollow metal frame (door, hardware, closure, etc.)

C4 Aluminum doors and frames

C5 Aluminum frames

C6 Wood door in aluminum frames (doors, hardware, closure, etc.)

C7 Folding doors, (bucks, trim, hardware, etc.)

C8 Rolling doors (bucks, trim, hardware, etc.)

C9 Fire doors, (bucks, trim, hardware, etc.)

C10 Steel doors, (bucks, trim, hardware, etc.

C11 Access doors (bucks, trim, hardware, etc.)

C12 Rixon hinges

C13 Wood windows (rough buck, sash, trim, hardware, screens,etc.)

C14 Metal windows (hardware, screens, etc.)

C15 Aluminum windows (hardware, screens, etc.)

C16 Barrowed lights

C17 Stud walls

C18 Furring

C19 Sheating

C20 Floor joist

C21 Sub floors

C22 Ceiling joist

C23 Rafters

C24 Canopy framing

C25 Gutter board

C26 Clear storm framing

C27 Fascia Bd.

C28 Soffit, rough framing, trim,. etc.)

C29 Skydomes (rough framing, trim, etc.)

C30 Cupolas, (rough framing, trim, etc.)

C31 Insulated panels

C32 Wood strips

C33 Shutters

C34 Venetian blinds

C35 Picture mould

C36 Wool platforms (rough framing, finish floor, trim, etc.)

C37 Medicine cabinet

C38 Locker cabinet

C39 Display case

C40 Telephone booths

C41 Coat racks

C42 Shelving

C43 Chalkboards

C44 Tackboards

C45 Wood handrails

C46 Wood paneling (furring, strips, panèling and related trim)

C47 Paneling - plastic faced

C48 Paneling - ceramic tile faced

C49 Base board

C50 Quarter round

C51 Bathroom accessories (towel bars, paper holders, soap tray, mirrors, etc.)

C52 Movable partitions

C53 Wood trusses - exposed (set, clean, trim, etc.)

C54 Wood columns - exposed (set, clean, trim, etc.)

C55 Exposed deck

C56 Insulation

C57 Filing cabinet

STEELWORK "S"

S Reinforcing steel (place rods, watch pour, shake out steel, carry steel, etc.)

S1 Structural steel (columns, beams, sheets, etc.)

S2 Bar joist (set joist, weld joist, brace joist)

S3 Steel stairs

S4 Metal siding

S5 Corruform (steel deck)

S6 Steel handrain (bolted to stair)

S7 Steel handrail (bolted to wall)

S8 Pipe rails

S9 Ornamental railings

S10 Steel ladders

S11 Steel doors, (frames, head, closures, etc.)

S12 Anchor bolts

S13 Access doors

S14 Roof hatches

S15 Metal expansion joints

S16 Grating

S17 Shelf angles anchored in concrete

S18 Loading dock bumpers

S19 Wire mesh

S20 Pre-case concrete joist

S21 Pre-case concrete beams

S22 Pre-case concrete columns

S23 Skylight framing

MASONRY "M"

M Face brick with backup (lay, clean down, scaffold, haul brick, etc)

M1 Face brick veneer (lay, clean down, scaffold, haul brick, etc.)

M2 Face brick interior (lay, clean down, scaffold, haul brick, etc.)

M3 Face brick Circular wall (lay, clean down, scaffold, haul brick, etc.)

M4 Face brick columns (lay, clean down, scaffold, haul brick, etc.)

M5 Face brick pilasters (lay, clean down, scaffold, haul brick, etc.)

M6 Face brick sills (lay, clean down, scaffold, haul brick, etc.)

M7 Face brick soldier coureses (lay, clean down, scaffold, haul brick, etc.)

M8 Face brick stack bond (lay, clean down, scaffold, haul brick,etc.)

M9 Tuckpoint brick

M10 Face brick pattern (lay, clean down, scaffold, haul brick, etc.)

M11 Cut stone

M12 Cut stone with backup

M13 Cut stone with veneer

M14 Cut stone belt course or copings

M15 Cut stone columns

M16 Haydite block partitions

M17 Haydite block partitions stack bond

M18 Haydite block partitions vertical stack bond

M19 Concrete block walls (ext.)

M20 Concrete block wall partitions

M21 Glazed tile (regular bond, lay, point, clean, unload, etc.)

M22 Glazed tile (stack bond, lay, point, clean, unload, etc.)

M23 Glazed tile (vertical stack bond, lay, point, clean, unload, etc.)

M24 Glazed tile (columns stack bond, lay, point, clean, unload, etc.)

M25 Rubble stone with backup

M26 Rubble stone columns

M27 Red clay tile partitions

M28 Red clay tile floor slab

M29 Fire brick

M30 Precast panels

M31 Tooth pilasters

M32 Manholes

M33 Common brick

OVERHEAD "O"

0 Superintendent

01 Engineer

02 Misc. haul

03 Miscellaneous

04 Back-charges

05 Temp. weather prot.

06 Temp. sheds and office

PAYROLL JOURNAL

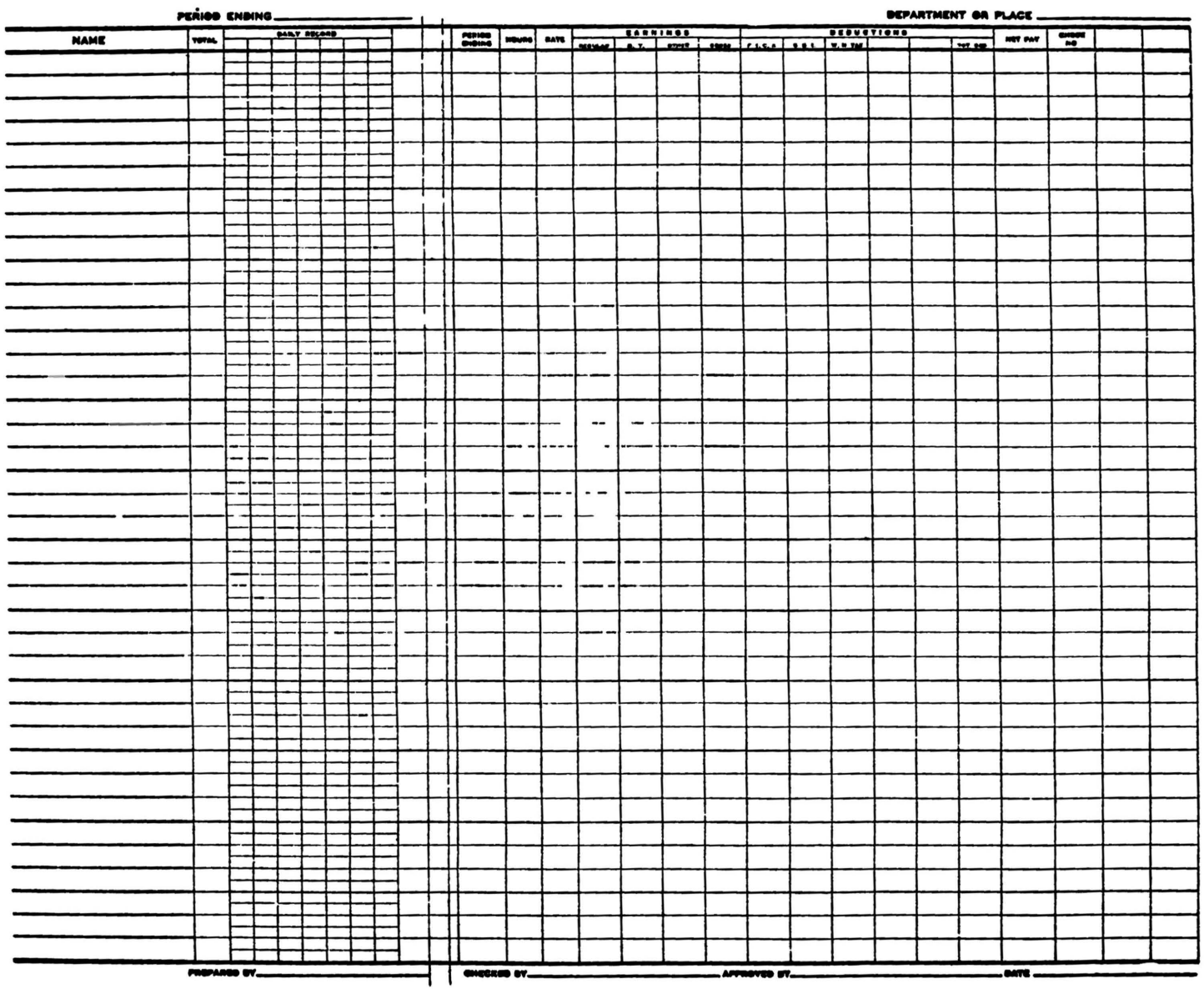


FIGURE 61. CONTRACTOR C - PAYROLL JOURNAL

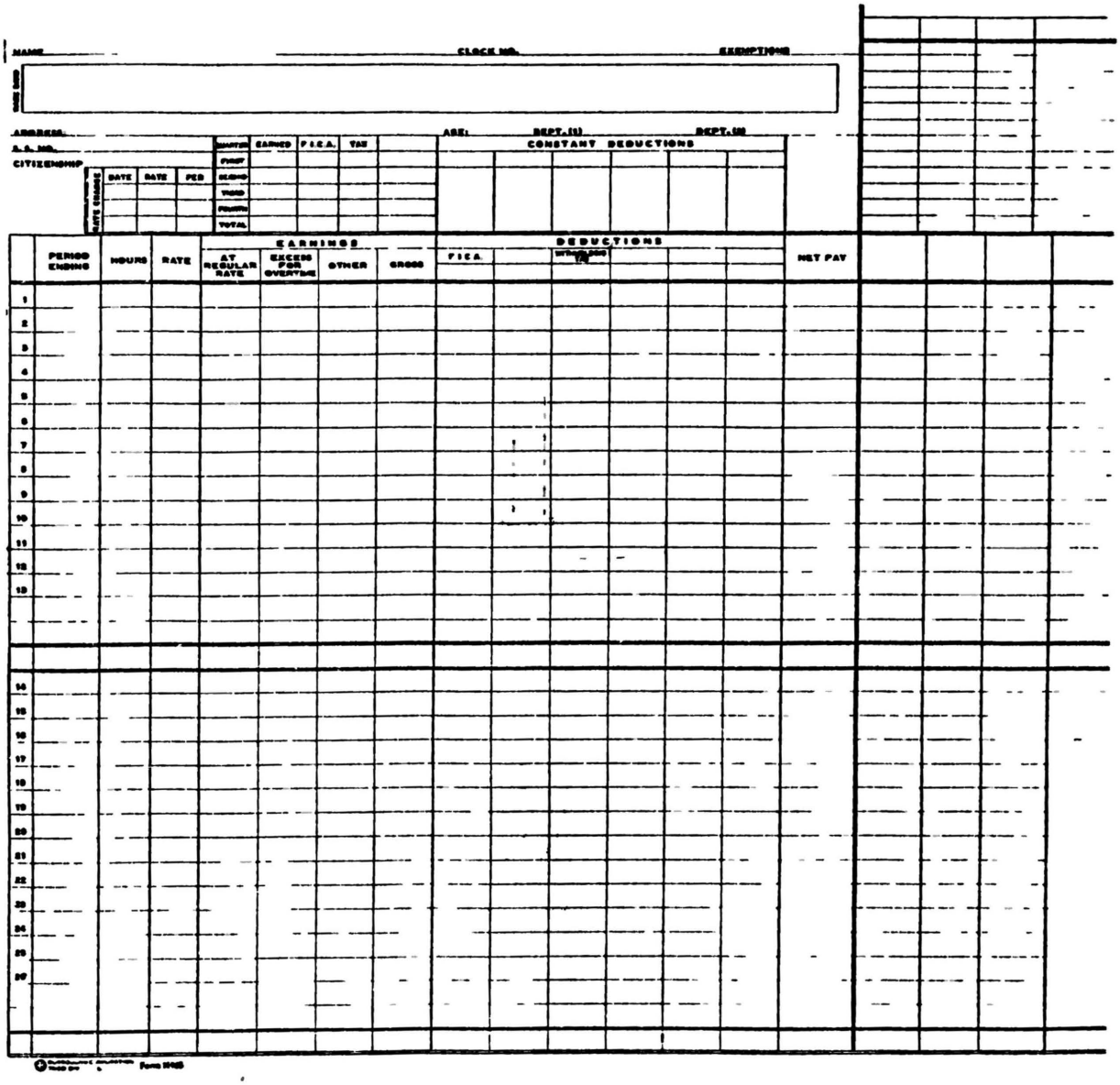


FIGURE 62. CONTRACTOR C - INDIVIDUAL PAYROLL RECORD

The material cost originate with the delivery of material to the field. The job superintendent receives a copy of the invoice which is referenced to the job. The material received is checked again t the invoice to assure that it is correct. The office also receives billings from the suppliers. The invoices from the field are checked by the accountant or secretary to verify that they agree with the bills from the supplies. When large quantities of material are delivered such as a railroad car of lumber it is charged to the company as a whole and then distributed and charged to the different jobs as needed. An accounts Payable Ledger is not kept by Contractor C due to the fact that he makes it a point to pay all bills within the time necessary to receive discounts. If an excess of material is charged to one job and it can be used on another job a Material Transfer Slip of the type shown in Figure 63. When material is paid for entries are made in the General Journal, and Job Cost Ledger (Figure 64).

Equipment Costs for the equipment owned by the contractor is recorded in the field by the superintendent. The information is recorded on the form shown in Figure 65. These forms are sent to the office weekly to be recorded to the Job Cost Ledger.

The charges for hired trucks or equipment are recorded on forms of the type shown in Figure 66. The form provides an original and a carbon copy. The original copy is kept by Contractor C and the carbon by the equipment operator for billing information. The original copies are sent to the office to be checked against the bill received from the supplier. When the bill is paid the information is recorded to Job Cost Ledger and the General Journal.

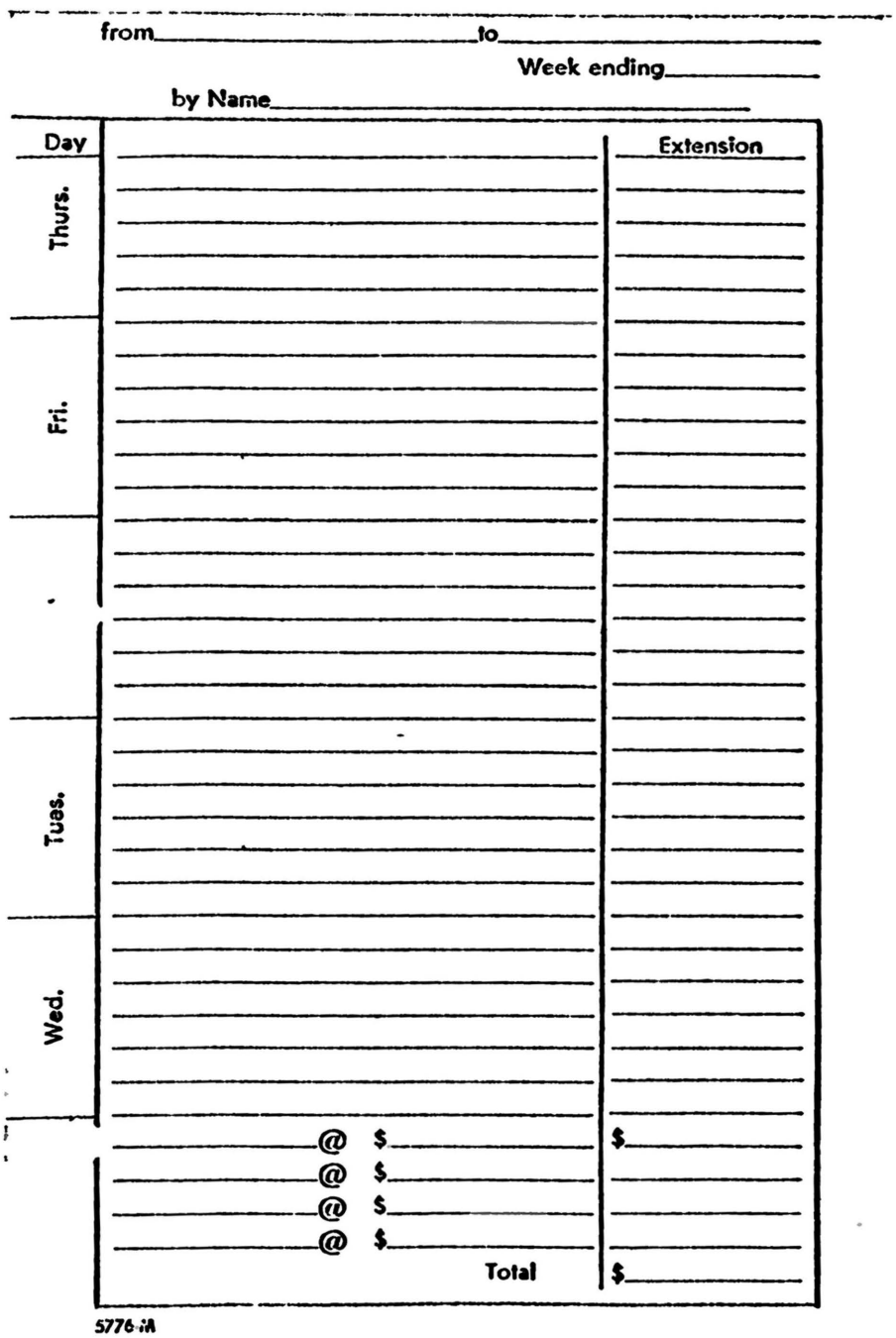


FIGURE 63. CONTRACTOR C - MATERIAL TRANSFER SLIP

JOB COST LEDGER

	TOTAL	LABOR	MATERIAL	SUB CONTRACTS	MISC EXPENSE	JOB NUMBER	DATE	NAME	DEBIT	CREDIT	DISCOUNT	ALLOWANCE	NET AMOUNT	NO	✓	
1						1										1
2						2										2
3						3										3
4						4										4
5						5										5
6						6										6
7						7										7
8						8										8
9						9										9
10						10										10
11						11										11
12						12										12
13						13										13
14						14										14
15						15										15
16						16										16
17						17										17
18						18										18
19						19										19
20						20										20
21						21										21
22						22										22
23						23										23
24						24										24

FIGURE 64. CONTRACTOR C - JOB COST LEDGER

Job_____ Week Ending_____

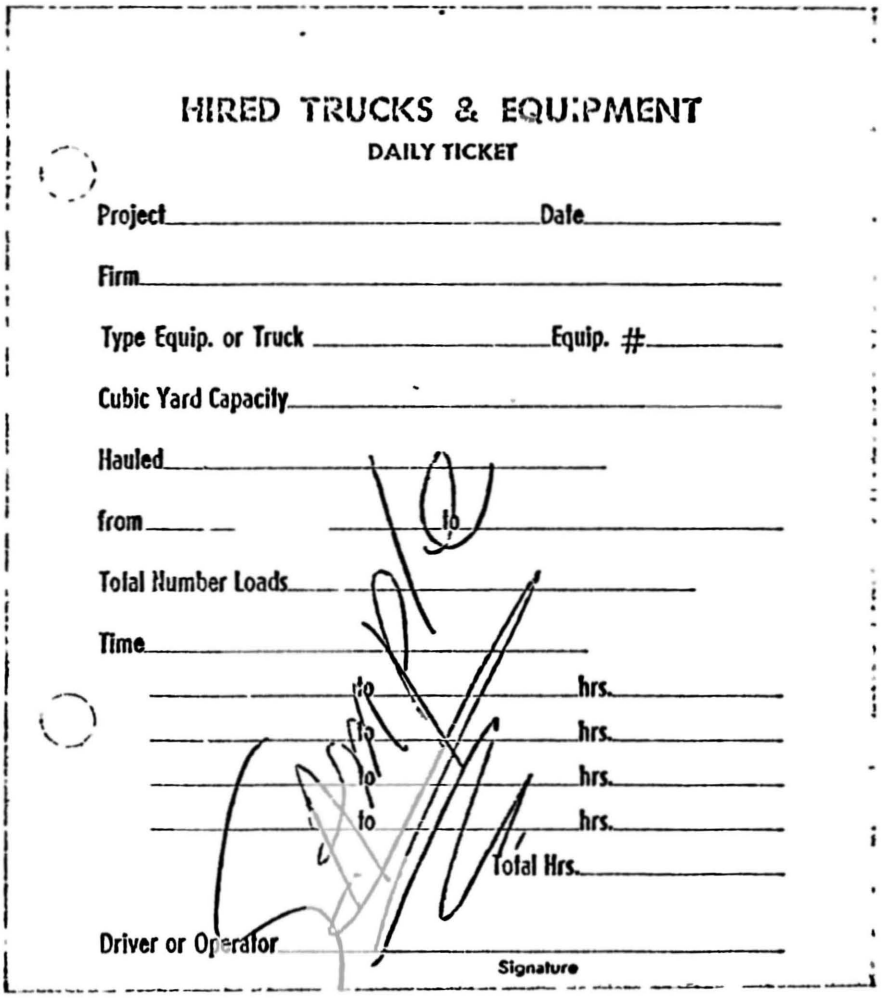
Operator Name_____

Back Charge_____

933 Cat _____ hrs. @_____	_____
955 Cat _____ hrs. @_____	_____
HC 68 Crane ☐ operate ☐ oil _____ hrs. @_____	_____
HC 78 Crane ☐ operate ☐ oil _____ hrs. @_____	_____
Backhoe _____ hrs. @_____	_____
Ford Tractor _____ hrs. @_____	_____
International Tractor _____ hrs. @_____	_____
Wench truck _____ hrs. @_____	_____
Hydrocrane _____ hrs. @_____	_____
Air Compressor _____ hrs. @_____	_____
Welder _____ hrs. @_____	_____
Pickup truck #_____ _____ hrs. @_____	_____
Flat Bed Dump #_____ _____ hrs. @_____	_____
_____ other _____ hrs. @_____	_____
Total	$_____

5776-E

FIGURE 65. CONTRACTOR C - EQUIPMENT COST SLIP



HIRED TRUCKS & EQUIPMENT

DAILY TICKET

Project _____ Date _____

Firm _____

Type Equip. or Truck _____ Equip. # _____

Cubic Yard Capacity _____

Hauled _____

from _____ to _____

Total Number Loads _____

Time _____

_____ to _____ hrs.

_____ to _____ hrs.

_____ to _____ hrs.

_____ to _____ hrs.

Total Hrs. _____

Driver or Operator _____

Signature

FIGURE 66. CONTRACTOR C - HIRED EQUIPMENT COST SLIP

Before any project begins a form of the type shown in Figure 67 is made out for each subcontractor showing contract price for the subcontract work to be done. As the job progresses and payments are made to the subcontractor, these payments are recorded. This gives the contractor a general idea of how the subcontractor is progressing.

Overhead costs are applied periodically to the accumulated cost when the contractor submits requests for payment to the owner.

Time accounting is carried out by Contractor C primarily in the interest of future estimating. It is not used during the actual project in an effort to check the time progress.

When the project is completed the contractor seperates the actual manhour records according to the type of work performed. This data is then used as historical data in future estimating.

5. P ogress Reporting

The contractor does not pay significant attention to the time consumed on the job unless he notices a definate time problem or when time reporting is required by the owner. In these cases he uses the bar chart where possible and a personal estimate of the progress. The actual manhours spent on the job do not provide the basis for his estimate of progress.

The contractor's main interest in terms of progress is the matter of cost. All actual cost records are examined carefully and checked against the estimated costs in order to determine whether the project is overrun or underrun on costs. This check is made periodically as deemed necessary by the contractor.

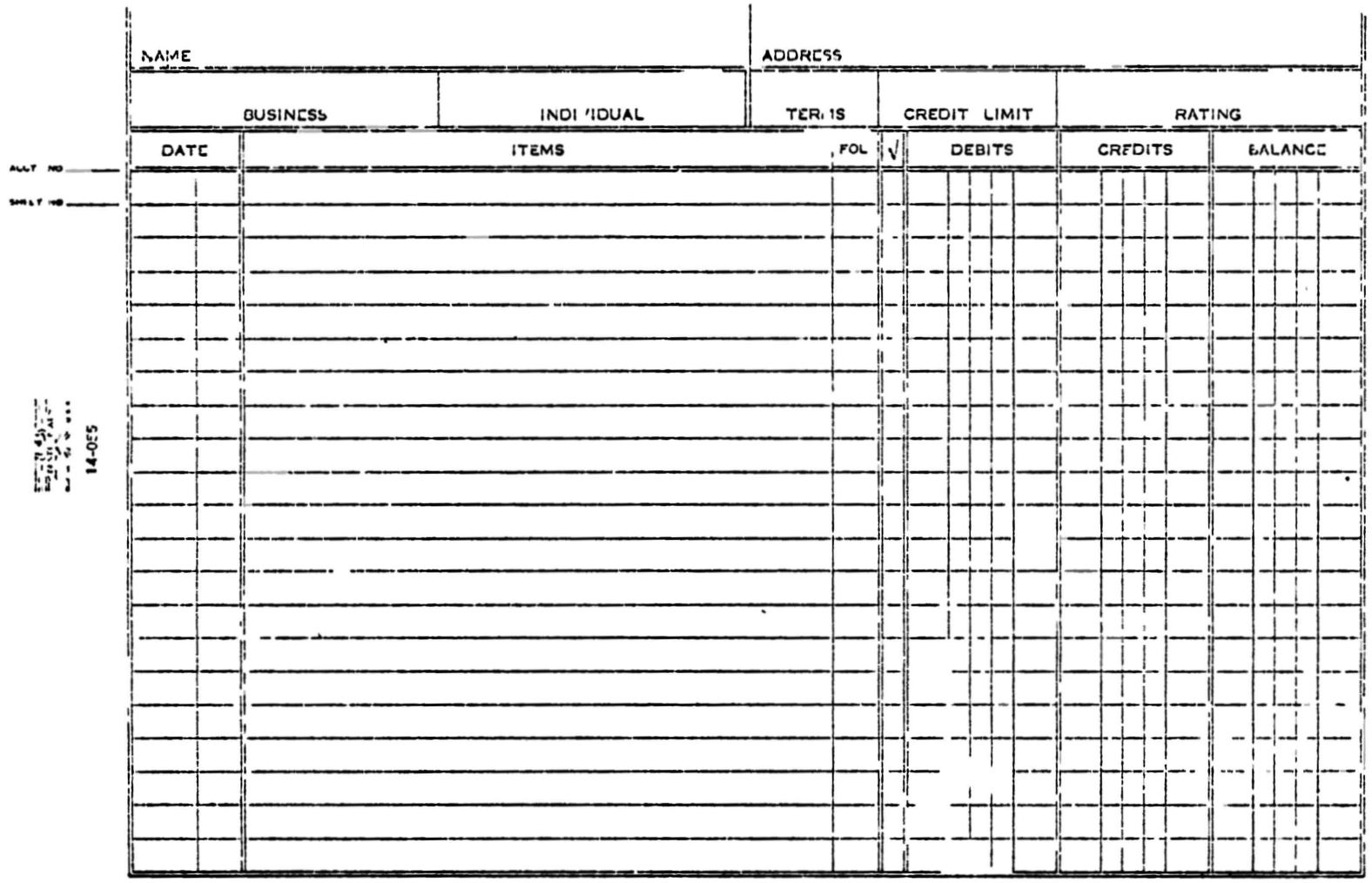


FIGURE 67. CONTRACTOR C - SUBCONTRACT COST RECORD

IV. DISCUSSION

A. Estimate- ime and Cost

The estimate is the starting point of any job, and as has been previously stated, provides a part of the basis for the determination of whether the contractor will or will not make a profit once he has received the contract for the job. The PMS-360 system may add on an important factor to the contractor's estimate which is a requirement for detailed analysis and preplanning. This is espec'ally true in the matter of time estimating.

The system requires that a PERT network be prepared if the system is to be used for time control. This makes it necessary for the job to be broken down into rational and logical work packages and that the sequence in which these packages are to take place be established. This has the advantage of assuring the contractor of a well established knowledge and unders+anding of the requirements of the job prior to actual construction. It also gives him a better insight into any part of the job which would require special preplanning.

Once the breakdown of the job has been completed and the sequence of operations determined, it is necessary to prepare an estimate of the duration of each of these activitie-. Therefore, a competent time estimate must be made in order forthe network to serve the purpose for which it is designed. These durations can be estimated based on historical data, personal experience, published references or contact with other people.

Of the three contractors investigated, only Contractor B has used the network method of scheduling projects. He does not use the labor

estimates in determining the estimated durations for the activities but bases the estimates on experience and judgement. Contractors A and C use the bar chart for scheduling their projects. Contractor A bases his duration estimates on experience and judgement but Contractor C uses his manpower estimates in combination with his experience and judgement. He also has a file of historical data which is useful in preparing these estimates.

When the cost estimate is considered, the main advantage of preparing the network is that the contractor is provided with a better insight into special conditions in the work that might result in a more accurate estimate.

B. Schedule

Contractors are usually interested in the time progress of a project especially in cases where a specific completion date has beed established. The PERT network provides the basis for the contractor's determination of time progress. By use of the PERT network with the sequence of operations and time durations known, the contractor can determine the expected start, latest start, expected finish, and latest finish of each work package or activity. This information is presented in the Activity Time Status Report (Page 49). He can determine the amount of primary slack available (the amount of time the activity can be delayed without affecting the total duration of the project), and t e secondary slack (the amount of time available for each activity which is a predecessor to one which has been assigned a secondary complet'on date). He can determine the total expected duration of the project and the activities which are critical in attaining this duration.

The critical activities are those which have no slack time and must

therefore be completed within the duration specified or the total project will be delayed. These are the activities on which management control should be concentratted. For control purposes, the PERT network is superior to the bar chart used by any of the contractors investigated since much more control detail is shown. Also the bar charts used by these contractors do not show a dependency relationship between the parts of the project. It is, therefore, necessary to estimate the starting date of each part of the bar chart as well as their durations. In the PERT presentation only durations are estimated; the estimate dates are obtained by calculations based upon the network logic.

Although contractors have the capability of foreseeing possibilities of delay due to their experience in the construction field, it will be easier to see these possibilities with the project broken down into well defined work packages as it is in the PERT network.

C. Resource Allocation

The importance of having material delivered on time and having the proper work force available have already been stressed. These items can be critical factors in both time and cost control when a delay results.

All three contractors which were investigated order material either upon award of the contract or in some cases before the contract is awarded. They stated that they based the requested delivery dates on the bar chart which they have prepared. Due to the fact that their bar charts are not broken down to a detailed level, it is difficult to determine accurate delivery dates. The PERT network, which provides the contractor with an expected start date for each activity allows the contractor to determine a much more accurate delivery date. Should a

delay occur somewhere in the project the new desired delivery date can be determined with proper updating. With this information available, the contractors should be able to eliminate a large part of the project delays due to late material delivery except in cases where the supplier is at fault.

None of the contractors investigated schedule their manpower needs. As a result, problems sometimes arise such as Contractor A's statement that due to his demand for labor on short notice he often gets poor quality labor with resulting low productivity. It was also stated that union problems may arise due to fluctuation in demand for labor. The Manpower Loading Report (Page 58) which is provided by the PMS-360 system summarizes the estimated man-hours of all crafts which will be required for any specific period of time on the project. This allows the contractor to schedule his manpower needs to fit the requirements. In this manner he can prevent delays in the project due to lack of manpower. He can also improve the quality of his manpower.

Another aspect concerning manpower is the matter of leveling manpower needs. "Leveling" manpower means that the contractor attempts to schedule manpower in order to keep a relatively constant work force in a given trade. None of the contractors investigated level manpower beyond the point of using a basic work crew and adding to it or deducting from it as needed.

Another advantage that can be gained by use of the PERT network is in scheduling equipment needs. The contractor can forsee when equipment is required on any part of the project with greater accuracy due to the use of the PERT network. He is able to see situations where he will need the same piece of equipment on more than one part of a

project at the same time. By investigating which activity is most critical or has the least slack he can determine which activity has priority. Contractor B does schedule equipment needs by use of his bar chart but as previously stated his bar chart does not contain enough detail to accurately schedule equipment needs. This contractor stated that if a conflict does come about he rents the needed piece of equipment in order to prevent a delay.

This method does prevent the delay but it requires the contractor to pay for renting the piece of equipment to do the work that his own equipment could have performed had he been able to foresee the difficulty and reschedule activities.

Contractors A and C do not schedule equipment needs when a conflict occurs they must either suffer a delay rent the needed equipment or reschedule the activities. In either of these cases they will be faced with additional cost. Some of which could be prevented if this problem could have been anticipated.

D. Accounting

Each contractor investigated has an manual accounting system which serves his purpose and has for past years. However, many large and progressive firms are going to the use of varied computer oriented cost and time accounting systems. The advantages offered by these programs can be obtained by smaller organizations by contracting with a computer service firm to produce the desired reports from data supplied by the contractor.

The system cannot replace the field accounting system used by any contractor. This field accounting is the backbone of his cost control. PMS/360 can, however, strengthen his cost control due to the amount of

detail required by the system. It requires that the contractor record in the field both the time and cost data according to the work package to which it applies and to the field code of accounts used by the contractor. This requires that the contractor have a well defined field code of accounts for distributing costs to the separate parts of the job such as the one used by Contractor C. By doing this the contractor acquires a much better record of where costs were actually incurred. However, a large amount of additional time and effort is required in properly accumulating and recording the data in the field. The hiring of a timekeeper may be necessary in order to prevent the job superintendent or foreman from being overloaded with work. This additional effort results in greater expenditures and should be considered as a possible disadvantage to the system.

The accounting procedures presented by the PMS-360 system can replace much of the present accounting carried out by the contractor above the job level. It can replace everything except the payroll records and the accounts payable and receivable records and with some modification could be programmed to handle these areas also. Cost and time data is input to the system according to resource code, activity to which the cost is assigned, charge numbers, performing department, and level of the Work Breakdown Structure and Organization Analysis Table. This information is all stored for later reporting. Reports on time and cost can be called for at any level in the project from the individual work packages up to the total project. This serves as the Job Cost Ledger used by all of the contractors. Also due to the system's capability of handling multiple projects it can give a report with combined cost data for all projects with which the company is

involved. This capability replaces the need for a General Journal. The primary advantage gained from use of the PMS-360 system for accounting is the fact that a variety of reports are more readily available without the large amount of manual labor and time consumption required to produce them by the present accounting systems used by the contractors. Thus control procedures are more effective due to the relative ease of producing a report as well as the variety available to help pin-point a problem.

E. Reporting

In this area the system holds another of its advantages. The versatility of the reports which can be produces is unmatched by the reporting capabilities of contractors investigated.

The system produces three time reports, the first being the Activity Time Status Report (Page 49), which is the basic report of the time control procedure. In it each activity within the project is listed with its expected and latest start and completion dates, and slack information. The data for this report can be sorted in a number of different ways depending upon the desires of the user. The information provided is useful in ordering material, and scheduling manpower and equipment needs. It also serves as the basis for evaluati g time progress. Throughout the project the contractor can look at the progress in the field and compare it with the network schedule. He can examine each activity and judge whether or not it will be computed by the expected completion date or the latest completion date or if it is going to overrun in time. When he feels that an activity is going to be completed late he can apply management action in an attempt to stay on schedule. The contractor can concentrate his management efforts

on the activities which have little slack or no slack at all because it is these activities which will delay the project if they overrun on time. As activities are completed their actual durations should be input to the system in order to keep it updated. This allows the contractor to re-evaluate the progress of the work completed and also to look ahead to the work to be completed. In some cases the actual progress may cha ge the critical path of the network. The contractor will then be able to concentrate his efforts on the new critical activities.

The Activity Time Status report gives a better basis for time control than the bar charts used by the contractors investigated and will help the contractor to see problem areas so that action can be taken to eliminate these problems.

The second time report is the Functional Bar Graph. If the contractor is more satisfied with the use of the bar chart or some of his management personnel better understand the bar chart, it can be produced from the network information. It will be a detailed bar chart and will serve better in time control than the bar charts presently used by the contractors.

The last time report is the PERT Milestone Report. It is used for reporting on events within the project which the cntractor feels are key events. It is probably not applicable to use in the construction field because there is little difference of importance among the activities of a project. The decision on whether this report would be used would be based on the need and desire of the contractor.

The cost reports produced by the system provide an automatic basis of comparison between actual cost and estimated cost as well as providing other distinct advantages. Among these advantages is the

matter of application of overhead, distribution of the cost for a specific activity over the time period of the activity and the multiple levels of reporting.

The reports presently produced by each of the contractors are management oriented rather than being oriented toward the project manager or craft foreman. It is these men who are closely related with the costs incurred on the job and if they wer properly informed they could probably make many on the job changes which would result in cost saving. Under the present reporting system the supervisory personnel on the job must wait for management to analyze the reports and make suggestions for cost control. This point is shown in Figures 35, 47, and 59 which are the Cost Information Flow Charts for each of the contractors.

By the use of the PMS-360 cost reports can be produced at the management level which replace the reports presently used by the contractor. In addition reports can be produced for the lowest level of management responsible for job control. The reports which produce information primarily at the management level are the Management Summary Report, Financial Plan and Status Report, and Program Outlook Graph.

The Management Summary Report (Page 53) provide current and projected data for the total project as well as each of the subdivisions within the project. The subdivisions are presented on seperate lines with their estimated value and actual cost of work performed to date. The amount of overrun or underrun in cost is then calculated and presented. The system then projects the total cost to the end of the job according to a linear projection based on the time assigned to

the project andthe time and cost consumed to date. From the cost to date information the contractor makes a revised estimate to enter to the aystem. The system then determines the totalprojected job overrun or underrun. It also presents information on the most criticalalack and a graphical representation of the scheduled, actual, earliest and latest completion dates. The contractor is then able to determine the cost status of the project and its parts by comparing the value with the cost to date. He can also forsee the future status of the job from the projected cost data compared to the estimated value. The contractor will be able to locate problem areas and make control decisions.

The Financial Plan and Status Report (Page 56) presents cost information on an accounting-period basis and is useful if the system is used fo accounting. The cost data is presented on an incremental basis with the actual, planned, latest revised estimate, and overrun or underrun of the cost presented for each accounting period. The same information is presented for the cumulative cost to date of the activity or total project. The Financial Plan and Status Report can replace the job cost ledger used by the contractors investigated. Aside from being used for accounting, it is not particularly useful for control. However it can be used for requesting payment from the owner for work completed in each accounting period. It replaces forms such as the Contractor's Monthly Estimate used by Contractor A and shown in Figure 45.

The Program Outlook Graph (Page 60) gives management a more general view of the profect by placing the budget, actual, and projected outlook cost data for the total project in graphical form. It is useful only in determining the cost status of the job as a whole and could not serve as a basis for any detailed management decisions. Its use for a

contractors would be limited.

The reports which provide information for the lower functional levels of management include the Program/Project Status Report, Organization Status Report, Cost Category Report and Manpower Loading Report.

The Program/Project Status Report (Page 63) presents comprehensive time and cost information in one report. Each of the activities is listed with its corresponding time and cost information including the schedule earliest, and latest completion dates and most critical slack and the cost of work performed to date and projected totals at completion. It is ideal for use by project superintendents because it presents both time and cost information in one report. From the time information given the superintendent can compare the actual cost with the estimated value and overrun or underrun to determine cost status. He can also see the projected cost values in comparison with the planned cost. This gives him an outlook on the future of the project. The Program/Project Status Report is useful due to the fact that the superintendent is able to spot problem areas himself without having to wait for management to analyze reports and inform him of problems.

The Organization Status Report (Page 65) presents time and cost information sorted by the responsible organization such as the ompany itself or a subcontractor; the performing department such as carpentry, plumbing or electrical; or resource code such as the seperate labor or material classifications. It is useful in distributing time and cost information to the seperate functional managers on the job such as the carpenter foreman, electrical foreman, or plumbing foreman. In case where these foremen are given control responsibility they can analyze the time and cost information for the work for which they are responsible just as the superintendent analyzed the overall job. When control

responsibility is not placed on them, management or the superintendent can analyze these reports and use them to point ut to the seperate foreman their problem areas and discuss with them the methods of eliminating these problems.

The Cost Category Report (Page 69) presents 'to date' and projected man-hour and cost information divided into the seperate cost categories of the job such as excavation, carpentry, plumbing, etc., as they are listed on the original estimate sheet. It may not be desired for use because it repeats the information contained on other reports in a different form.

The Manpower Loading Report (Page 58) is useful in scheduling manpower needs and in comparing the estimated manpower required with the actual man-hours consumed. At the beginning of the project it is used to schedule the manpower needs throughout the project from the budget value. As the project progresses the actual man-hours consumption is input to the computer and presented on the report. Management can now determine if the actual man-hours is in agreement with those budgeted. If they do not closely agree, action can be taken to determine why and also an attempt made to solve the manpower problem. The most critical slack can also be presented in order to determine what activity might be able to spare manpower. The activities with the most slack time could be delayed in order to switch manpower to another activity which is critical or behind schedule.

It is doubtful whether a contractor would desire to use all of the reports just discussed. How many of these reports and which ones would be used would be decided based on the contractor's requirements.

F. System Installation and Training

The use of the PMS-360 system requires the availability of a computer. Computer availability can be obtained in two ways. First, the computer can be rented by the contractor for use in carrying out the system. It is doubtful that a contractor of the size being discussed could afford this cost unless the computer was to be used for enough other applications to keep it busy. The renting of a computer also requires that the contractor hire someone trained in the operation of the computer. This presents additional costs.

The second alternative is the renting of computer services offered by a firm or organization having persons trained in the operation of the computer. This eliminates some expenditures ev though the renting of computer time is expensive.

The training of all personnel involved with the use of the PMS-360 system is essential to its use. This initial training will be expensive. Field personnel must be trained in the proper collection of data for the system and in interpreting the reports produced by the system. Also office personnel must be trained to place the field data in the proper format for input to the computer. Management personnel must also be trained to properly interpret the reports produced. All personnel involved will have to be trained in the use of the PERT network method of scheduling as it is the basis for much of the PMS-360 system.

V. CONCLUSION

A number of advantages have been shown which can occur from the use of the Project Management System/360 as compared to the time and cost control methods of the contractors investigated. Among these are scheduling of construction projects, resource allocation, and reporting capabilities. However, before a contractor decided to use this system he should thoroughly examine the PMS-360 system as well as his own system in order to determine if the added control is necos ary for his operations. There are situations where the type and size of projects carried out by a contractor would prevent the cortractor from benefiting from the use of the PMS-360 system.

For contractors in the size range investigated, a matter which needs further investigation in determining the feasibility of the use of PMS-360 is the cost of making the system operational, including training personnel in the use of the system, and the actual cost of using the system.

Should an investigation of this type reveal that the cost incurred is not a major disadvantage, the PMS-360 system will allow the contractor to maintain a current awareness of project status, both time and cost, and allow him to beco e capable of applying his efforts to assure proper project performance.

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